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INORGANIC COMPOSITION OF A PEAT AND OF THE PLANT FROM WHICH IT WAS FORMED

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INTRODUCTION

The comparison of the inorganic composition of a peat with that of the material from which it was formed can seldom be made with any certainty, because generally several species of plants have contributed to the deposit. The extensive saw-grass peat deposits found in the Everglades of Florida offer an unusual opportunity to make this comparison, since all indications point to their having been formed by the accumulation of the remains of a single species of plant, saw grass (*Cladium effusum*).

DESCRIPTION AND COMPOSITION OF SAW GRASS

Saw grass is a member of the sedge family and is found chiefly along the banks of streams or ponds and in swamps throughout the southeastern States. By far the largest colony is found in the Everglades, where many thousand acres are covered with an almost impenetrable growth, which reaches a height of 8 to 10 feet in many places. Saw grass resembles ordinary grasses in appearance and derives its name from the fact that the edges and back of the midrib of the leaves are serrated.

On account of the difficulty experienced in obtaining entire plants for analysis, separate samples of leaves, root crowns, and roots were gathered, care being taken to remove all extraneous material. In ashing the samples an electric muffle furnace, fitted with an automatic temperature control set at 550° C., was used to prevent the loss of alkalies by volatilization.

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The determination of silica was made according to the method of the Association of Official Agricultural Chemists,[1] the figure stated thus representing silica of constitution only. Phosphoric acid and the alkalis were determined in the usual manner, and the remaining constituents by the modified Glaser method described by Mellor.[2] The significance of separate values for iron and aluminium oxids was not deemed of importance, and therefore they are reported together. A test was made for titanium, but it was not found in any part of the saw-grass plant. The results of the analyses are given in Table I.

TABLE I.—*Composition of saw grass*

Constituent.	Percentage of dry material.			
	Leaves.	Root crowns.	Roots.	Average.
Silica (SiO_2)	0.50	0.32	0.10	0.30
Iron oxid (Fe_2O_3) and alumina (Al_2O_3)	.09	.08	.16	.11
Lime (CaO)	.59	.59	.52	.57
Magnesia (MgO)	.12	.12	.10	.11
Soda (Na_2O)	.27	.06	.14	.16
Potash (K_2O)	.39	.31	.35	.35
Phosphoric acid (P_2O_5)	.08	.09	.05	.07
Nitrogen	.90	.89	.62	.80

It will be noted that there is comparatively little variation in the composition of the three parts of the plant, with the possible exception of the silica content, and therefore the average of the values found for the three parts is taken as the composition of the saw grass for the subsequent comparisons. The values given are very near the true ones, even in the case of the silica, since it is probable that leaves and roots contribute in nearly equal amounts in the formation of peat.

DESCRIPTION AND COMPOSITION OF PEAT

The peat deposit in the Everglades resulting from the accumulation of the remains of saw grass and varying in depth to about 10 feet, covers a vast area. Near the surface the peat is brown in color, has a loose, fibrous structure, and is very light when dry. It has an ash content of from 7 to 10 per cent. At depths below the surface the material becomes darker in color and less fibrous in texture as the depth increases, grading finally into a black, plastic, compact mass almost free from plant fiber. The ash content also increases slightly with the depth, but even at depths of 6 or 7 feet no free mineral matter can be detected, except in limited

[1] WILEY, H. W., ed. OFFICIAL AND PROVISIONAL METHODS OF ANALYSIS, ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS, AS COMPILED BY THE COMMITTEE ON REVISION OF METHODS. U. S. Dept. Agr. Bur. Chem. Bul. 107, p. 22. 1907.

[2] MELLOR, J. W. A TREATISE ON QUANTITATIVE INORGANIC ANALYSIS. p. 606-609. London, Philadelphia, 1913.

areas where extraneous sand or calcium carbonate contaminate the material.

The samples used in this investigation are representative of about 12 taken from widely separated areas and can be looked upon as being typical of the peat deposit in the Everglades. Sample 1 was taken 9 miles from Lake Okeechobee near the North New River Canal at a depth of 0 to 60 inches. No. 1a is the subsoil of No. 1, its depth being 60 to 120 inches. Sample 2 was taken 20 miles from Lake Okeechobee, a few miles from the North New River Canal, at a depth of 0 to 25 inches, while No. 2a, its subsoil, represents the depth from 25 to 82 inches.

Analyses of this peat were made by practically the same methods used in the case of the ash of the saw grass. The results obtained are presented in Table II.

TABLE II.—*Composition of Everglades peat*

Constituent.	Percentage of dry material.			
	Peat 1.	Peat 2.	Peat 1a (subsoil of 1).	Peat 2a (subsoil of 2).[a]
Silica	1.95	2.04	1.98	3.02
Iron oxid and alumina	.69	.60	.93	1.12
Lime	3.02	2.74	4.67	4.27
Magnesia	.43	.44	.45	.70
Soda	.14	.19	.19	.25
Potash	.11	.06	.09	.06
Phosphoric acid	.13	.15	.07	.07
Nitrogen	3.32	3.84	2.83	2.75
Total ash	7.7	6.8	8.8	10.2

[a] This sample contained a small amount of extraneous sand.

COMPARISON OF PEAT AND SAW-GRASS ANALYSES

In comparing a soil with its parent substance in order to determine the amount of the various constituents removed during the transformation it must be assumed that one of the elements present was not removed at all, or at any rate to a slight extent only. Thus, Merrill [1] compares a granite rock with its resultant clay and assumes that the alumina content was unaltered, while Penrose [2] in comparing a limestone with its resultant clay assumes that no silica was lost during the change. In the present instance the silica was used as the basis of calculation, because it is undoubtedly the most stable constituent present under the conditions of peat formation—that is, continual submersion in water. Table III shows the relationship between the peat and the saw grass when the latter is calculated to the same silica content.

[1] MERRILL, G. P. WEATHERING OF MICACEOUS GNEISS IN ALBEMARLE COUNTY, VIRGINIA. *In* Bul. Geol. Soc. Amer., v. 8, p. 160. 1897.

[2] PENROSE, R. A. F. MANGANESE; ITS USES, ORES, AND DEPOSITS. Ann. Rpt. Geol. Survey Ark. 1890, v. 1, p. 179. 1891.

TABLE III.—*Comparison of the composition of peat and saw grass*

Constituent.	Peat 1.	Saw grass × silica ratio (6.5).	Percentage loss.	Peat 2.	Saw grass × silica ratio (6.8).	Percentage loss.
Silica	1.95	1.95	0.0	2.04	2.04	0.0
Iron oxid and alumina	.69	.72	4.2	.60	.75	20.0
Lime	3.02	3.70	18.4	2.74	3.88	29.3
Magnesia	.43	.72	40.3	.44	.75	41.3
Soda	.14	1.04	86.5	.19	1.09	82.6
Potash	.11	2.27	95.1	.06	2.38	97.5
Phosphoric acid	.13	.45	71.1	.15	.48	68.7
Nitrogen	3.32	5.20	36.1	3.84	5.44	29.4

The losses obtained for the two samples of surface peat cited agree very well except in the case of the iron oxid and alumina, and even here the variation is not excessive. No comparison was made with the subsoil peats because they have been subjected to the leaching action of water so long that more or less of all the elements present must have been removed. In the subsoil 1a there appears to have been a considerable loss of silica, while both samples contain much less nitrogen than those taken from nearer the surface. However, this is to be expected when it is considered that hundreds, if not thousands, of years have elapsed since the deposition of these lower strata.

The comparatively small loss of lime suffered by the saw grass may seem surprising at first, and it is unusual, as this constituent is leached very readily from ordinary soils. There are two possible explanations for its behavior under the circumstances. In the first place, the lime is present in the plant for the most part as difficultly soluble compounds (calcium oxalate, etc.), and in the second place, owing to the great abundance of calcium carbonate in the Everglades, the solvent action of the waters upon the lime in the peat must be far less than it would be under other conditions.

In the formation of ordinary soils, potash is held by adsorption, and, hence, suffers a lower percentage loss than some of the less soluble elements; but this constituent is leached very readily from leaves and vegetation,[1] and nearly the entire amount originally present in the saw grass has been removed in the transformation to peat.

The enormous accumulation of nitrogen in the peat is an interesting phase of the change undergone by the saw grass. The loss of nitrogen seems to be very gradual, and even in the subsoil there is still a very high percentage of this element. The prevailing poor conditions for bacterial activity while the peat is being formed both preclude the possibility of nitrogen fixation, and also account for the greater stability of the nitrogen in the peat than in ordinary soils, wherein the nitrogen is oxidized to nitrate and thus leached.

[1] LE CLERC, J. A., and BREAZEALE, J. F. PLANT FOOD REMOVED FROM GROWING PLANTS BY RAIN OR DEW. *In* U. S. Dept. Agr. Yearbook, 1908, p. 389-402. 1909.

In Table IV a comparison is made of the losses suffered by three widely differing soil-forming materials in their transformation to soils. As previously stated, the behavior of the lime in the saw grass is strikingly different from that in the other cases cited and considerably more potash also was removed.

TABLE IV.—*Comparison of the losses of three soil-forming materials in their transformation to soils*

Constituent.	Percentage losses suffered by parent material in soil formation.		
	Arkansas limestone (8 parts yield 1 of soil).[a]	Granite (1.7 parts yield 1 of soil).[b]	Saw grass (7 parts yield 1 of peat).
Silica	0.00	52.45	0.00
Iron oxid	89.56	14.35	12.2
Alumina	11.35	00.00	
Lime	98.93	100.00	23.8
Magnesia	89.38	74.70	40.8
Potash	66.36	83.52	96.3
Soda	53.26	95.03	84.6
Nitrogen	.....	.....	32.8

[a] PENROSE, R. A. F. loc. cit. [b] MERRILL, G. P. loc. cit.

CONCLUSIONS AND SUMMARY

In this article the inorganic composition of typical samples of Everglades peat is given together with analyses of the parent material from which the peat was formed—namely, saw grass (*Cladium effusum*). Brief descriptions of both products are also given. Assuming that no silica was lost during the transformation, about 7 parts of saw grass were required to yield 1 of peat. Based on this assumption, the constituents were leached to the following extent:

Iron oxid and alumina, 12.2 per cent; lime, 24 per cent; magnesia, 41 per cent; potash, 96 per cent; soda, 84.6 per cent; phosphoric acid, 70 per cent; and nitrogen, 33 per cent. The losses suffered by two other common soil-forming substances, granite and limestone, are shown for the sake of comparison.

DIGESTIBILITY OF CORN SILAGE, VELVET-BEAN MEAL, AND ALFALFA HAY WHEN FED SINGLY AND IN COMBINATIONS

By P. V. EWING, *Animal Husbandman, Texas Agricultural Experiment Station* and F. H. SMITH,[1] *Georgia Agricultural Experiment Station*

INTRODUCTION

This paper is the third in a series of investigations on the associative action of various feeds. The results with rations made up of corn silage, cottonseed meal, and starch [2] and those made up of corn silage and cottonseed meal [3] have been published, and the present article deals with the question of the digestibility of rations made up of corn silage, velvet-bean meal, and alfalfa hay. The investigation was conducted with the view of studying the extent and causes of fluctuations in the total nutrient digestibility induced by the combinations of these feeds, and the relationship of these fluctuations to the feeding practice.

PLAN OF INVESTIGATION

The steers used were the high-grade 2-year-old north-Georgia Shorthorns which had been used in the nutrition work of the winter of 1915–16 (previously reported).[4]

The corn silage and alfalfa hay were both produced on the Station farm and were of average grade. The velvet-bean meal was from commercial stock and came from near the southern Georgia-Alabama line. The average analyses of these feeds are given in Table I.

TABLE I.—*Average percentage composition of the feeds used*

Feed.	Dry matter.	Ether extract.	Crude fiber.	Ash.	Nitrogen.	Nitrogen-free extract.
Silage	26.29	0.773	7.304	1.180	0.252	15.46
Alfalfa hay	91.02	2.675	30.770	6.865	2.564	34.68
Velvet-bean meal	89.37	4.576	14.430	4.250	2.764	48.84

[1] F. H. Smith is now a lieutenant in the Aviation Branch of the United States Army. The work on which this paper is based was done while the senior and junior writers were connected with the Georgia Agricultural Experiment Station in the capacities of Animal Husbandman and Chemist, respectively.

[2] EWING, P. V., and WELLS, C. A. THE ASSOCIATIVE DIGESTIBILITY OF CORN SILAGE, COTTONSEED MEAL, AND STARCH IN STEER RATIONS. Ga. Agr. Exp. Sta. Bul. 115, p. 269–296, 7 diagr. 1915.

[3] EWING, P. V., WELLS, C. A., and SMITH, F. H. THE ASSOCIATIVE DIGESTIBILITY OF CORN SILAGE AND COTTONSEED MEAL IN STEER RATIONS. pt. 2. Ga. Agr. Exp. Sta. Bul. 125, p. 149–164, 1 fig. 1917.

[4] EWING, P. V., and SMITH, F. H. A STUDY OF THE RATE OF PASSAGE OF FOOD RESIDUES THROUGH THE STEER AND ITS INFLUENCE ON DIGESTION COEFFICIENTS. *In* Jour. Agr. Research, v. 10, no. 2, p. 55–63. 1917.

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Nine different rations were fed, and the digestion trials were made in triplicate, different quantities of the feeds being used in each of the three trials. The first three rations contained but one feed each, the next three contained two feeds each, and the last three contained three feeds each. A feature of the rations was the variations presented as to quantities and proportions, and in each of the last three rations the quantity in one feed was varied, while the other two were kept constant. This provided means for checking the influences exerted by the specific components of the rations. The composition of the various rations and the weight of the feces excreted daily are given in Table II. The percentage composition of the feces is given in Table III.

TABLE II.—*Weights of animals, feed, and feces*

Ration No.	Digestion trial No.	Steer No.	Average weight.	Average daily feed.			Average weight of feces excreted daily.
				Silage.	Velvet-bean meal.	Alfalfa.	
			Kgm.	*Kgm.*	*Kgm.*	*Kgm.*	*Kgm.*
I	a	63	260	6	.....	.....	2. 280
	b	64	284	8	.....	.....	4. 705
	c	62	259	10	.....	.....	5. 045
II	a	61	273	.....	.....	3. 000	4. 642
	b	66	280	.....	.....	4. 000	6. 120
	c	65	282	.....	.....	4. 292	6. 850
III	a	65	270	.....	3. 50	.....	2. 609
	b	65	288	.....	3. 50	.....	2. 368
	c	65	277	.....	3. 50	.....	2. 521
IV	a	66	284	2	.....	4. 000	6. 651
	b	65	293	3	.....	3. 000	6. 298
	c	61	278	4	.....	2. 000	4. 934
V	a	64	298	4	3. 50	.....	5. 072
	b	63	282	6	2. 75	.....	5. 749
	c	62	271	8	2. 00	.....	6. 475
VI	a	64	290	.....	2. 00	3. 000	8. 128
	b	63	274	.....	2. 80	2. 800	7. 745
	c	62	290	.....	3. 00	2. 000	6. 480
VII	a	62	306	8	2. 00	2. 000	9. 950
	b	63	318	6	2. 00	2. 000	9. 193
	c	64	335	4	2. 00	2. 000	8. 372
VIII	a	64	335	4	2. 00	2. 000	8. 372
	b	61	262	4	1. 50	2. 000	6. 367
	c	66	298	4	2. 50	2. 000	9. 217
IX	a	64	335	4	2. 00	2. 000	8. 372
	b	62	318	4	2. 00	2. 500	7. 638
	c	63	318	4	2. 00	3. 000	8. 610

TABLE III.—*Percentage composition of the feces of steers*

Ration No.	Digestion trial No.	Dry matter.	Ether extract.	Crude fiber.	Ash.	Nitrogen.	Nitrogen-free extract.
I	a	20.34	0.459	4.115	2.276	0.391	11.05
	b	15.48	.445	3.008	1.714	.313	8.36
	c	15.07	.346	3.113	1.467	.300	8.27
II	a	21.76	.972	8.238	2.677	.507	6.70
	b	21.72	1.035	8.336	2.200	.520	6.90
	c	21.28	.998	8.331	2.291	.464	6.76
III	a	20.50	1.888	4.159	2.818	.983	5.49
	b	19.70	1.086	4.355	2.324	.841	8.68
	c	20.205	1.592	4.231	2.633	.931	6.665
IV	a	24.24	1.097	8.222	2.552	.541	8.99
	b	20.06	.920	6.635	2.221	.437	7.55
	c	21.53	.931	6.668	2.330	.498	8.49
V	a	19.42	.900	4.262	1.641	.628	8.69
	b	18.17	.691	4.373	1.577	.547	8.11
	c	15.60	.444	3.638	1.426	.448	7.29
VI	a	16.97	.965	6.118	1.660	.428	5.55
	b	19.40	.955	6.658	1.812	.565	6.44
	c	18.05	.799	6.218	1.929	.555	5.64
VII	a	17.83	.611	5.787	1.699	.405	7.20
	b	19.50	.727	6.361	1.865	.473	7.59
	c	17.39	.750	5.716	1.779	.455	6.30
VIII	a	17.39	.750	5.716	1.779	.455	6.30
	b	20.23	.800	6.126	2.319	.550	7.55
	c	16.37	.689	4.723	1.916	.454	6.20
IX	a	17.39	.750	5.716	1.779	.455	6.30
	b	19.49	.778	6.215	2.279	.502	7.08
	c	20.08	.811	6.444	2.293	.518	7.30

The equipment used and the general methods of weighing and sampling the feeds were similar to those previously described.[1] The digestion trials were of 12 days' duration each, with a minimum preliminary feeding period of 18 days. The quantity of feed was so gauged that there were no orts, and if a steer failed to eat its feed, the trial with that animal was discontinued.

DISCUSSION OF RESULTS

The digestion coefficients, with which we are primarily concerned, obtained for the several rations are given in Tables IV to X, being summarized and averaged in Tables VIII, IX, and X. In each instance the starting point for these studies is the result of feeding-alone experiments, probably the most accurate guide on the digestion of a specific food, especially when the metabolic products are taken into account. However, this has not been done in this study.

[1] EWING, P. V., WELLS, C. A., and SMITH, F. H. Op. cit.

TABLE IV.—*Digestion coefficients of the total nutrients of each ration*

Ration No.	Digestion trial No.	Dry matter.	Ether extract.	Crude fiber.	Ash.	Nitrogen.	Nitrogen free extract.
I	a	70. 58	78. 26	78. 54	26. 76	40. 00	72. 85
	b	65. 38	66. 13	75. 69	13. 83	25. 00	68. 23
	c	71. 09	77. 92	78. 49	37. 29	40. 00	73. 03
II	a	63. 02	43. 75	58. 61	39. 81	68. 83	70. 13
	b	62. 67	41. 12	58. 57	50. 91	68. 93	69. 60
	c	62. 68	40. 87	56. 78	46. 78	70. 91	68. 91
III	a	82. 90	69. 38	78. 42	50. 34	73. 20	91. 63
	b	85. 10	83. 75	79. 61	63. 09	79. 38	90. 05
	c	83. 72	75. 00	78. 81	55. 71	75. 26	90. 17
IV	a	61. 31	40. 16	60. 28	43. 14	66. 67	64. 76
	b	64. 12	43. 69	63. 40	41. 91	67. 06	68. 38
	c	63. 02	45. 88	63. 73	37. 50	59. 02	68. 06
V	a	76. 44	75. 92	72. 90	57. 65	70. 09	81. 05
	b	74. 10	76. 74	69. 94	51. 60	65. 93	79. 48
	c	74. 04	81. 17	72. 97	48. 60	61. 33	78. 68
VI	a	69. 48	54. 65	58. 99	53. 61	73. 49	77. 65
	b	70. 24	63. 55	59. 24	54. 99	70. 47	78. 67
	c	74. 01	72. 78	61. 55	52. 83	73. 14	83. 10
VII	a	68. 93	70. 67	61. 29	46. 52	68. 25	75. 38
	b	65. 41	65. 10	56. 41	41. 30	66. 94	73. 14
	c	68. 75	64. 41	59. 95	44. 61	67. 24	76. 98
VIII	a	68. 75	64. 41	59. 95	44. 61	67. 24	76. 98
	b	69. 43	66. 88	65. 27	40. 32	65. 69	76. 48
	c	70. 45	67. 84	65. 69	38. 97	67. 69	77. 46
IX	a	68. 75	64. 41	59. 95	44. 61	67. 24	76. 98
	b	70. 89	68. 95	64. 82	42. 76	70. 54	78. 03
	c	68. 96	65. 52	63. 10	41. 72	68. 31	76. 14

TABLE V.—*Digestion coefficients of corn silage by difference* [a]

Ration No.	Digestion trial No.	Dry matter.	Ether extract.	Crude fiber.	Ash.	Nitrogen.	Nitrogen-free extract.
I	a	70. 58	78. 26	78. 54	26. 76	40. 00	72. 85
	b	65. 38	66. 13	75. 69	13. 83	25. 00	68. 23
	c	71. 09	77. 92	78. 49	37. 29	40. 00	73. 03
IV	a	49. 82	26. 67	79. 57	.....	.....	43. 37
	b	68. 06	47. 83	86. 30	18. 86	37. 50	65. 74
	c	63. 12	51. 61	75. 68	12. 77	10. 00	66. 35
V	a	54. 18	74. 19	62. 33	61. 70	20. 00	54. 69
	b	58. 78	78. 27	61. 87	43. 66	13. 33	63. 36
	c	65. 62	88. 71	70. 03	41. 49	20. 00	69. 28
VII	a	61. 34	87. 10	55. 99	38. 30	45. 00	66. 61
	b	47. 24	69. 57	39. 27	14. 08	26. 67	57. 43
	c	52. 95	67. 75	45. 21	19. 15	10. 00	63. 75
VIII	a	52. 95	67. 75	45. 21	19. 15	10. 00	63. 75
	b	62. 17	90. 32	70. 21	2. 13	10. 00	67. 48
	c	54. 75	80. 64	65. 41	.....	10. 00	60. 36
IX	a	52. 95	67. 75	45. 21	19. 15	10. 00	63. 75
	b	65. 87	106. 45	68. 84	6. 38	40. 00	70. 06
	c	59. 03	93. 55	63. 70	2. 13	10. 00	64. 40

[a] The alfalfa and velvet-bean meal digestion coefficients are based on feeding-alone experiments.

TABLE VI.—*Digestion coefficients of velvet-bean meal by difference* [a]

Ration No.	Digestion trial No.	Dry matter.	Ether extract.	Crude fiber.	Ash.	Nitrogen.	Nitrogen-free extract.
III	a	82. 90	69. 38	78. 42	50. 34	73. 20	91. 63
	b	85. 10	83. 75	79. 61	63. 09	79. 38	90. 05
	c	83. 72	75. 00	78. 81	55. 71	75. 26	90. 17
V	a	78. 33	75. 63	69. 70	65. 77	73. 20	83. 97
	b	76. 20	76. 19	60. 45	63. 25	71. 05	84. 06
	c	77. 78	83. 70	61. 94	67. 06	69. 09	85. 98
VI	a	79. 41	65. 22	62. 28	72. 94	78. 18	86. 29
	b	77. 66	76. 56	61. 88	69. 75	71. 43	85. 16
	c	81. 50	84. 67	66. 51	60. 16	75. 90	89. 50
VII	a	72. 75	82. 61	33. 56	63. 53	78. 18	72. 37
	b	63. 12	71. 74	19. 38	41. 18	72. 73	75. 85
	c	73. 42	72. 83	45. 33	49. 41	70. 91	84. 75
VIII	a	73. 42	72. 83	45. 33	49. 41	70. 91	84. 75
	b	77. 11	81. 16	68. 06	34. 37	68. 29	85. 95
	c	76. 32	77. 28	68. 42	33. 02	71. 01	84. 21
IX	a	73. 42	72. 83	45. 33	49. 41	70. 91	84. 75
	b	81. 03	85. 87	69. 20	42. 35	76. 36	88. 74
	c	77. 00	81. 52	64. 01	37. 65	70. 91	85. 16

[a] The corn-silage and alfalfa-hay digestion coefficients are based on feeding-alone experiments.

TABLE VII.—*Digestion coefficients of alfalfa hay by difference* [a]

Ration No.	Digestion trial No.	Dry matter.	Ether extract.	Crude fiber.	Ash.	Nitrogen.	Nitrogen-free extract.
II	a	63. 02	43. 75	58. 61	39. 81	68. 83	70. 13
	b	62. 67	41. 12	58. 57	50. 91	68. 93	69. 60
	c	62. 68	40. 87	56. 78	46. 78	70. 91	68. 91
IV	a	64. 91	34. 58	58. 08	44. 00	67. 96	63. 69
	b	62. 13	33. 75	59. 80	43. 69	70. 12	66. 18
	c	58. 51	27. 77	56. 74	39. 41	62. 74	63. 69
VI	a	60. 01	30. 00	52. 76	52. 42	71. 42	65. 51
	b	56. 85	42. 66	50. 00	54. 16	65. 27	61. 77
	c	59. 39	64. 81	49. 26	49. 63	68. 62	67. 29
VII	a	51. 92	53. 70	36. 74	50. 36	70. 58	58. 50
	b	42. 52	35. 18	30. 07	36. 49	64. 70	48. 67
	c	52. 63	37. 03	42. 27	41. 60	62. 74	61. 38
VIII	a	52. 63	37. 03	42. 27	41. 60	62. 74	61. 38
	b	57. 96	50. 00	54. 14	35. 77	62. 74	64. 69
	c	53. 68	44. 44	51. 87	27. 73	62. 74	58. 40
IX	a	52. 63	37. 03	42. 27	41. 60	62. 74	61. 38
	b	60. 58	55. 23	54. 35	38. 95	70. 31	67. 12
	c	58. 44	48. 75	53. 30	37. 86	66. 23	64. 45

[a] The corn-silage and velvet-bean meal digestion coefficients are based on feeding-alone experiments.

TABLE VIII.—*Average corn-silage digestion coefficients when velvet-bean meal and alfalfa-hay coefficients are based on feeding-alone experiments*

Method of feeding.	Dry matter.	Ether extract.	Crude fiber.	Ash.	Nitrogen.	Nitrogen-free extract.
Alone	69. 02	74. 10	77. 57	25. 96	35. 00	71. 37
With alfalfa hay	60. 33	42. 04	80. 52	15. 82	23. 75	58. 49
With velvet-bean meal	59. 53	80. 39	64. 74	48. 95	17. 78	62. 44
With alfalfa hay and velvet-bean meal	56. 58	81. 21	55. 45	15. 06	19. 07	64. 18
Average	61. 37	69. 43	69. 57	26. 45	23. 90	64. 12

TABLE IX.—*Average velvet-bean meal digestion coefficients by difference when alfalfa-hay and corn-silage coefficients are based on feeding-alone experiments*

Method of feeding.	Dry matter.	Ether extract.	Crude fiber.	Ash.	Nitrogen.	Nitrogen-free extract.
Alone	83.91	76.04	78.95	56.36	75.95	90.62
With corn silage	77.42	78.51	64.03	65.36	71.11	84.67
With alfalfa hay	79.52	75.48	63.03	67.46	75.17	86.98
With corn silage and alfalfa hay	74.17	77.63	50.96	44.48	72.25	82.95
Average	78.76	76.92	64.38	58.42	73.62	86.31

TABLE X.—*Average alfalfa-hay digestion coefficients by difference when velvet-bean meal and corn-silage coefficients are based on feeding-alone experiments*

Method of feeding.	Dry matter.	Ether extract.	Crude fiber.	Ash.	Nitrogen.	Nitrogen-free extract.
Alone	62.79	41.91	57.99	45.83	69.56	69.55
With corn silage	61.85	32.03	58.21	42.37	66.94	64.52
With velvet-bean meal	58.75	45.82	50.67	52.07	68.44	64.86
With corn silage and velvet-bean meal	53.67	33.26	45.25	39.11	65.06	60.66
Average	59.27	38.26	53.03	44.85	67.50	64.90

Reference to the tables show that, as a general proposition, the digestibility of a feed is greatest when fed alone, next greatest when fed in combination with one other feed, and least when fed in combination with the two other feeds. In this connection, however, the apparent loss in digestibility is not necessarily all attributable to the combination, for the total dry matter consumed in the rations containing two feeds was greater than in the rations containing one feed, and the total dry matter of the rations made up of three feeds was greater than the rations containing two feeds. Thus, the quantity of the feed in the larger rations probably had a depressing effect on digestibility. Kellner[1] cites his own experiments with steers fed mixed rations which show an apparent decrease in digestibility with an increasing quantity of feed, and Armsby and Fries[2] state that their results seem to—

> indicate clearly a real, although slight, effect of increasing quantity in diminishing the percentage digestibility.

Our results have shown the same slight decline, but it is not probable that the total decline in digestion coefficients obtained with three feeds compared with two, and with two feeds compared with one, is accounted

[1] KELLNER, OSKAR. DIE ERNÄHRUNG DER LANDWIRTSCHAFTLICHEN NUTZTIERE. Aufl. 6, p. 48. Berlin, 1912.

[2] ARMSBY, H. P., and FRIES, J. A. THE INFLUENCE OF TYPE AND OF AGE UPON THE UTILIZATION OF FEED BY CATTLE. U. S. Dept. Agr. Bur. Anim. Indus. Bul. 128, p. 28. 1911.

for by the increased quantity of feed. We must therefore conclude that in general, so far as the feeds we are studying are concerned, the combination with other feeds has a depressing effect on digestion. This does not necessarily follow for all the individual nutrients.

It is evident from a study of the tables that, so far as the average apparent digestion coefficients of silage are concerned, nothing is especially abnormal or noteworthy. It is true that the nitrogen (crude protein) digestion presents some irregularities when fed in combination with other feeds, but when fed alone these irregularities are not out of the ordinary. The amount of nitrogen in corn silage is so small that variations are likely to occur. Ash digestion also not only shows considerable irregularity at times but frequently shows a negative coefficient. This same condition has been noted in previous digestion experiments.

The apparent coefficients obtained for velvet-bean meal are of special interest on account of the relatively few digestion trials that have been made with this comparatively important feed. From our results it is seen that, as a whole, this feed is rather highly digestible; and when fed alone approximately 84 per cent of the dry matter is digested. The apparent digestibility of none of the nutrients averaged less than 58 per cent.

The apparent digestion coefficients for alfalfa hay present no marked irregularities. They do show the same general decline as a result of combination and quantity of feed. This decline amounts to over 10 per cent from feeding alone to the combining of all three feeds in Ration VII, where the total quantity of dry matter consumed was greater than in any other ration.

Thus, these results show no great variations from what might have been expected. While it is true that from an economic standpoint we are interested in that combination of feeds which will give the greatest digestibility for all the nutrients of the rations, these results do show no marked decline as a result of food combinations. If marked declines existed, their presence would be magnified by the determination of digestion coefficients by difference, but here we have no marked variations from the normal and can therefore conclude that the combining of these feeds has resulted in no marked increase or decrease in apparent digestion coefficients.

When rations that contain silage, velvet-bean meal, and alfalfa hay are fed, the tendency seems to be to lower the digestibility of the whole slightly below the calculated digestion coefficients. There are indications also that slightly better use is made of the feeds fed when the ration is made up of silage and one of the protein feeds than when both the protein feeds are fed, and that the most complete digestion takes place with silage and alfalfa rather than with the silage and velvet-bean meal, although the difference is small.

We appreciate the effect of individual variation in digestion and the slight variations which are likely to occur as a result of making the digestion trials at different times. The trials were made in triplicate, and the time factor was minimized by the method of planning the experiment. The slight variations noted are so general that it is hardly conceivable that they could in any way be accounted for by the possible errors mentioned.

CONCLUSIONS

Aside from the actual digestion coefficients obtained by the feeding of these feeds alone and under the different combinations, a review of the coefficients seems to justify the following conclusions:

(1) The combining of these feeds in general tends toward lowering the digestibility of the several nutrients of the rations.

(2) The digestion of corn silage, alfalfa hay, and velvet-bean meal is apparently fairly constant under the different combinations.

(3) More accurate digestion coefficients are obtained by feeding-alone experiments, where such are possible, rather than by the usual difference method.

(4) Greater variations are presented in the apparent digestibility of nitrogen and ash than in other nutrients.

(5) Compared with similar feeds, velvet-bean meal is apparently well digested.

EFFECTS OF VARIOUS SALTS, ACIDS, GERMICIDES, ETC., UPON THE INFECTIVITY OF THE VIRUS CAUSING THE MOSAIC DISEASE OF TOBACCO

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In the course of the writer's investigations of the mosaic disease of tobacco (*Nicotiana* spp.) many experiments have been carried out to determine the effects of different concentrations of salts, acids, alkalis, germicides, etc., upon the infectivity of the virus. The object in view was to throw some light on the question of the nature of the causal infective agent and the degree of resistance of this infective principle to the various chemical and germicidal treatments used. In these experiments all concentrations stated as 1 gm. of reagent in 100 c. c., 200 c. c., etc., of solution refer to 1 gm. of actual water-free salt or other reagent in the indicated volume of solution. The method of preparation of the various concentrations has been uniform. For determining the action of various concentrations of these substances, a double-strength concentration was first made with distilled water. Ten c. c. of virus were then added to 10 c. c. of the solution, the concentration being brought down to the strength desired. By using this method of preparation, the virus itself is uniformly diluted to half its original strength in all solutions. As the undiluted stronger concentrations (see Table I) frequently injure the leaf tissues severely, or even kill the plants outright if inoculated into them, it was sometimes necessary to dilute the solutions with several volumes of water at the time the inoculations were made.

The results of the various concentrations of substances used are shown in Table I and text following.

TABLE I.—*Effects of various chemicals on the infectivity of the virus of the mosaic disease of tobacco*

NITRIC ACID

Concentration.	Solution prepared.	Inoculation made.	Plants used.	Results.
1 gm. to 500 c. c. of virus solution...	June 9, 1914	June 23, 1914 (14 days later).	10 Connecticut Broadleaf.	10 plants mosaic.
1 gm. to 800 c. c. of virus solution...	....do....	....do....	....do....	9 plants mosaic.
1 gm. to 1,000 c. c. of virus solution..	....do....	....do....	....do....	Do.
1 gm. to 1,600 c. c. of virus solution..	....do....	....do....	....do....	10 plants mosaic.
1 gm. to 1,800 c. c. of virus solution..	....do....	....do....	....do....	Do.
1 gm. to 2,000 c. c. of virus solution..	....do....	....do....	....do....	Do.
1 gm. to 2,600 c. c. of virus solution..	....do....	....do....	....do....	Do.
Virus without addition.....	....do....	....do....	....do....	Do.
Tap water only (control).....	....do....	....do....	....do....	All healthy.

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TABLE I.—*Effects of various chemicals on the infectivity of the virus of the mosaic disease of tobacco*—Continued

NITRIC ACID—continued

Concentration.	Solution prepared.	Inoculation made.	Plants used.	Results.
1 gm. to 200 c. c. of virus solution	Sept. 5, 1914	Sept. 9, 1914 (4 days later).	10 Connecticut Broadleaf.	7 plants mosaic.
1 gm. to 300 c. c. of virus solution	do	do	do	Do.
1 gm. to 400 c. c. of virus solution	do	do	do	9 plants mosaic.
1 gm. to 500 c. c. of virus solution	do	do	do	7 plants mosaic.
Virus without addition	do	do	do	9 plants mosaic.
Tap water only (control)	do	do	do	All healthy.
1 gm. to 100 c. c. of virus solution	Jan. 7, 1915	Jan. 8, 1915 (1 day later).	do	Do.
1 gm. to 200 c. c. of virus solution	do	do	do	7 plants mosaic.
1 gm. to 400 c. c. of virus solution	do	do	do	9 plants mosaic.
1 gm. to 600 c. c. of virus solution	do	do	do	10 plants mosaic.
1 gm. to 800 c. c. of virus solution	do	do	do	9 plants mosaic.
Tap water only (control)	do	do	do	All healthy.
1 gm. to 50 c. c. of virus solution	Nov. 30, 1915[a]	Dec. 17, 1915 (17 days later).	do	Do.
1 gm. to 100 c. c. of virus solution	do	do	do	1 plant mosaic.
1 gm. to 200 c. c. of virus solution	do	do	do	3 plants mosaic.
1 gm. to 300 c. c. of virus solution	do	do	do	5 plants mosaic.
1 gm. to 400 c. c. of virus solution	do	do	do	6 plants mosaic.
1 gm. to 500 c. c. of virus solution	do	do	do	9 plants mosaic.
1 gm. to 600 c. c. of virus solution	do	do	do	8 plants mosaic.
1 gm. to 800 c. c. of virus solution	do	do	do	9 plants mosaic.
1 gm. to 1,000 c. c. of virus solution	do	do	do	7 plants mosaic.
Virus without addition	do	do	do	8 plants mosaic.
Tap water only (control)	do	do	do	All healthy.

HYDROCHLORIC ACID

1 gm. to 50 c. c. of virus solution	Apr. 25, 1914	Apr. 27, 1914 (2 days later).	10 Connecticut Broadleaf.	All healthy.
1 gm. to 200 c. c. of virus solution	do	do	do	Do.
1 gm. to 400 c. c. of virus solution	do	do	do	Do.
1 gm. to 800 c. c. of virus solution	do	do	do	Do.
1 gm. to 1,000 c. c. of virus solution	do	do	do	4 plants mosaic.
1 gm. to 2,000 c. c. of virus solution	do	do	do	8 plants mosaic.
1 gm. to 4,000 c. c. of virus solution	do	do	do	9 plants mosaic.
Virus without addition	do	do	do	10 plants mosaic.
Tap water only (control)	do	do	do	All healthy.
1 gm. to 100 c. c. of virus solution	Jan. 7, 1915	Jan. 8, 1915 (1 day later).	do	Do.
1 gm. to 200 c. c. of virus solution	do	do	do	6 plants mosaic.
1 gm. to 400 c. c. of virus solution	do	do	do	9 plants mosaic.
1 gm. to 600 c. c. of virus solution	do	do	do	Do.
1 gm. to 800 c. c. of virus solution	do	do	do	8 plants mosaic.
Tap water only (control)	do	do	do	All healthy.

PHOSPHORIC ACID

1 gm. to 50 c. c. of virus solution	May 25, 1914	May 29, 1914 (4 days later).	10 Maryland Mammoth.	3 plants mosaic.
1 gm. to 100 c. c. of virus solution	do	do	do	7 plants mosaic.
1 gm. to 200 c. c. of virus solution	do	do	do	Do.
1 gm. to 400 c. c. of virus solution	do	do	do	10 plants mosaic.
1 gm. to 500 c. c. of virus solution	do	do	do	9 plants mosaic.
1 gm. to 600 c. c. of virus solution	do	do	do	10 plants mosaic.
1 gm. to 800 c. c. of virus solution	do	do	do	Do.
1 gm. to 1,000 c. c. of virus solution	do	do	do	Do.
Virus without addition	do	do	do	Do.
Tap water only with weak solution phosphoric acid (control).	do	do	do	All healthy.
1 gm. to 10 c. c. of virus solution	June 9, 1914	June 19, 1914 (10 days later).	do	Do.
1 gm. to 20 c. c. of virus solution	do	do	do	1 plant mosaic.
1 gm. to 50 c. c. of virus solution	do	do	do	3 plants mosaic.
1 gm. to 100 c. c. of virus solution	do	do	do	Do.
1 gm. to 200 c. c. of virus solution	do	do	do	7 plants mosaic.
Virus without addition	do	do	do	10 plants mosaic
Tap water only with weak solution phosphoric acid (control).	do	do	do	All healthy.

[a] Virus filtered clear through filter paper before solutions were made.

TABLE I.—*Effects of various chemicals on the infectivity of the virus of the mosaic disease of tobacco*—Continued

PHOSPHORIC ACID—continued

Concentration.	Solution prepared.	Inoculation made.	Plants used.	Results.
1 gm. to 20 c. c. of virus solution	Nov. 30, 1915[a]	Dec. 18, 1915 (18 days later).	10 Maryland Mammoth.	All healthy.
1 gm. to 50 c. c. of virus solution	do	do	do	Do.
1 gm. to 100 c. c. of virus solution	do	do	do	4 plants mosaic.
1 gm. to 200 c. c. of virus solution	do	do	do	9 plants mosaic.
1 gm. to 400 c. c. of virus solution	do	do	do	8 plants mosaic.
Virus without addition	do	do	do	Do.
Tap water only (control)	do	do	do	All healthy.

CITRIC ACID

Virus saturated with citric acid crystals.	May 23, 1914	May 30, 1914 (7 days later).	10 Maryland Mammoth.	All healthy.
1 gm. to 50 c. c. of virus solution	do	do	do	6 plants mosaic.
1 gm. to 100 c. c. of virus solution	do	do	do	4 plants mosaic.
1 gm. to 200 c. c. of virus solution	do	do	do	7 plants mosaic.
Virus without addition	do	do	do	9 plants mosaic.
Tap water only (control)	do	do	do	All healthy.
1 gm. to 10 c. c. of virus solution	June 9, 1914	June 19, 1914 (10 days later).	do	Do.
1 gm. to 20 c. c. of virus solution	do	do	do	2 plants mosaic.
1 gm. to 50 c. c. of virus solution	do	do	do	5 plants mosaic.
1 gm. to 100 c. c. of virus solution	do	do	do	7 plants mosaic.
Virus without addition	do	do	do	10 plants mosaic.
Tap water and weak solution citric acid (control).	do	do	do	All healthy.
1 gm. to 20 c. c. of virus solution	Nov. 30, 1915	Dec. 21, 1915 (21 days later).	10 Connecticut Broadleaf.	Do.
1 gm. to 50 c. c. of virus solution	do	do	do	Do.
1 gm. to 100 c. c. of virus solution	do	do	do	1 plant mosaic.
1 gm. to 200 c. c. of virus solution	do	do	do	2 plants mosaic.
1 gm. to 400 c. c. of virus solution	do	do	do	3 plants mosaic.
Virus without addition	do	do	do	8 plants mosaic.
Tap water only (control)	do	do	do	All healthy.

ACETIC ACID

1 gm. to 10 c. c. of virus solution	May 25, 1914	June 5, 1914 (11 days later).	10 Maryland Mammoth.	All healthy.
1 gm. to 20 c. c. of virus solution	do	do	do	Do.
1 gm. to 50 c. c. of virus solution	do	do	do	3 plants mosaic.
1 gm. to 100 c. c. of virus solution	do	do	do	Do.
1 gm. to 200 c. c. of virus solution	do	do	do	5 plants mosaic.
1 gm. to 250 c. c. of virus solution	do	do	do	4 plants mosaic.
1 gm. to 500 c. c. of virus solution	do	do	do	10 plants mosaic.
1 gm. to 1,000 c. c. of virus solution	do	do	do	9 plants mosaic.
Virus without addition	do	do	do	Do.
Tap water only (control)	do	do	do	All healthy.
1 gm. to 20 c. c. of virus solution	Nov. 30, 1915	Dec. 18, 1915 (18 days later).	10 Connecticut Broadleaf.	Do.
1 gm. to 50 c. c. of virus solution	do	do	do	Do.
1 gm. to 100 c. c. of virus solution	do	do	do	1 plant mosaic.
1 gm. to 200 c. c. of virus solution	do	do	do	5 plants mosaic.
1 gm. to 400 c. c. of virus solution	do	do	do	9 plants mosaic.
1 gm. to 600 c. c. of virus solution	do	do	do	10 plants mosaic.
Virus without addition	do	do	do	8 plants mosaic.
Tap water only (control)	do	do	do	All healthy.

[a] Virus filtered clear through filter paper before solutions were made.

TABLE I.—*Effects of various chemicals on the infectivity of the virus of the mosaic disease of tobacco*—Continued

SODIUM CARBONATE

Concentration.	Solution prepared.	Inoculation made.	Plants used.	Results.
1 gm. to 50 c. c. of virus solution	Nov. 30, 1915[a]	Dec. 17, 1915 (17 days later).	10 Connecticut Broadleaf.	3 plants mosaic.
1 gm. to 100 c. c. of virus solution	do	do	do	4 plants mosaic.
1 gm. to 200 c. c. of virus solution	do	do	do	6 plants mosaic.
1 gm. to 300 c. c. of virus solution	do	do	do	9 plants mosaic.
1 gm. to 400 c. c. of virus solution	do	do	do	Do.
1 gm. to 500 c. c. of virus solution	do	do	do	8 plants mosaic.
1 gm. to 600 c. c. of virus solution	do	do	do	9 plants mosaic.
1 gm. to 800 c. c. of virus solution	do	do	do	8 plants mosaic.
1 gm. to 1,000 c. c. of virus solution	do	do	do	9 plants mosaic.
1 gm. to 1,200 c. c. of virus solution	do	do	do	7 plants mosaic.
1 gm. to 1,500 c. c. of virus solution	do	do	do	8 plants mosaic.
Virus without addition	do	do	do	Do.
Tap water only (control)	do	do	do	All healthy.

SODIUM HYDROXID

1 gm. to 50 c. c. of virus solution	Apr. 25, 1914	Apr. 27, 1914 (2 days later).	10 Maryland Mammoth.	All healthy.
1 gm. to 100 c. c. of virus solution	do	do	do	Do.
1 gm. to 200 c. c. of virus solution	do	do	do	Do.
1 gm. to 400 c. c. of virus solution	do	do	do	Do.
1 gm. to 800 c. c. of virus solution	do	do	do	Do.
1 gm. to 1,000 c. c. of virus solution	do	do	do	Do.
1 gm. to 2,000 c. c. of virus solution	do	do	do	1 plant mosaic.
1 gm. to 4,000 c. c. of virus solution	do	do	do	10 plants mosaic.
1 gm. to 8,000 c. c. of virus solution	do	do	do	Do.
Virus without addition	do	do	do	Do.
Tap water only (control)	do	do	do	All healthy.

MANGANESE SULPHATE

1 gm. to 12.5 c. c. of virus solution	Oct. 13, 1915[a]	Dec. 28, 1915 (76 days later).	10	7 plants mosaic.
1 gm. to 25 c. c. of virus solution	do	do	10	8 plants mosaic.
1 gm. to 50 c. c. of virus solution	do	do	10	9 plants mosaic.
1 gm. to 100 c. c. of virus solution	do	do	10	10 plants mosaic.
1 gm. to 200 c. c. of virus solution	do	do	10	Do.
1 gm. to 500 c. c. of virus solution	do	do	10	9 plants mosaic.
Tap water only (control)	do	do	10	All healthy.

SODIUM CHLORID

1 gm. to 25 c. c. of virus solution	Jan. 24, 1916	Mar. 5, 1916 (41 days later).	10	All healthy.
1 gm. to 50 c. c. of virus solution	do	do	10	Do.
1 gm. to 100 c. c. of virus solution	do	do	10	7 plants mosaic.
1 gm. to 200 c. c. of virus solution	do	do	10	Do.
1 gm. to 400 c. c. of virus solution	do	do	10	5 plants mosaic.
Tap water only (control)	do	do	10	All healthy.

ALUMINIUM SULPHATE

1 gm. to 100 c. c. of virus solution	Feb. 19, 1916	Mar. 7, 1916 (17 days later).	10	3 plants mosaic.
1 gm. to 200 c. c. of virus solution	do	do	10	10 plants mosaic.
1 gm. to 400 c. c. of virus solution	do	do	10	8 plants mosaic.
Virus without addition	do	do	10	6 plants mosaic.
Tap water only (control)	do	do	10	All healthy.

[a] Virus filtered clear through filter paper before solutions were made.

TABLE I.—*Effects of various chemicals on the infectivity of the virus of the mosaic disease of tobacco*—Continued

LITHIUM NITRATE

Concentration.	Solution prepared.	Inoculation made.	Plants used.	Results.
1 gm. to 50 c. c. of virus solution....	Feb. 19, 1916	Mar. 28, 1916 (19 days later).	10 Connecticut Broadleaf.	6 plants mosaic.
1 gm. to 100 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	9 plants mosaic.
1 gm. to 200 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	Do.
1 gm. to 400 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	Do.
1 gm. to 600 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	Do.
1 gm. to 800 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	8 plants mosaic.
Virus without addition.....	.....do.....	.....do.....	.....do.....	Do.
Tap water only (control).....	.....do.....	.....do.....	.....do.....	All healthy.

SODIUM NITRATE

1 gm. to 50 c. c. of virus solution....	Feb. 19, 1916	Mar. 28, 1916 (38 days later).	10 Connecticut Broadleaf.	10 plants mosaic.
1 gm. to 100 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	Do.
1 gm. to 200 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	Do.
1 gm. to 400 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	Do.
1 gm. to 600 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	Do.

LEAD NITRATE

1 gm. to 200 c. c. of virus solution...	Feb. 19, 1916	Mar. 28, 1916 (38 days later).	10 Connecticut Broadleaf.	9 plants mosaic.
1 gm. to 400 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	10 plants mosaic.
1 gm. to 600 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	Do.
1 gm. to 800 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	Do.
1 gm. to 1,000 c. c. of virus solution.	.....do.....	.....do.....	.....do.....	Do.
Virus without addition (used for sodium nitrate and lead nitrate solutions).	.....do.....	.....do.....	.....do.....	Do.
Tap water only (control) for sodium nitrate and lead nitrate solutions.	.....do.....	.....do.....	.....do.....	All healthy.

SILVER NITRATE

1 gm. to 100 c. c. of virus solution...	Nov. 15, 1916[a]	Dec. 18, 1916 (33 days later).	10 Connecticut Broadleaf.	2 plants mosaic.
1 gm. to 300 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	9 plants mosaic.
1 gm. to 500 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	10 plants mosaic.
1 gm. to 800 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	Do.
1 gm. to 1,000 c. c. of virus solution.	.....do.....	.....do.....	.....do.....	Do.
1 gm. to 1,500 c. c. of virus solution.	.....do.....	.....do.....	.....do.....	Do.
Virus without addition.....	.....do.....	.....do.....	.....do.....	8 plants mosaic.
Tap water only (control).....	.....do.....	.....do.....	.....do.....	All healthy.

MERCURIC CHLORID

1 gm. to 100 c. c. of virus solution...	Oct. 8, 1915[b]	Nov. 13, 1915 (36 days later).	10.....	All healthy.
1 gm. to 300 c. c. of virus solution...	.....do.....	.....do.....	10.....	6 plants mosaic.
1 gm. to 500 c. c. of virus solution...	.....do.....	.....do.....	10.....	8 plants mosaic.
1 gm. to 1,000 c. c. of virus solution.	.....do.....	.....do.....	10.....	9 plants mosaic.
1 gm. to 1,500 c. c. of virus solution.	.....do.....	.....do.....	10.....	10 plants mosaic.
Virus without addition.....	.....do.....	.....do.....	10.....	9 plants mosaic.
Tap water only (control).....	.....do.....	.....do.....	10.....	All healthy.
1 gm. to 100 c. c. of virus solution...	Nov. 16, 1916[a]	Dec. 19, 1916 (33 days later).	10 Connecticut Broadleaf.	4 plants mosaic.
1 gm. to 200 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	2 plants mosaic.
1 gm. to 400 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	5 plants mosaic.
1 gm. to 600 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	6 plants mosaic.
1 gm. to 800 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	9 plants mosaic.
1 gm. to 1,000 c. c. of virus solution.	.....do.....	.....do.....	.....do.....	Do.
1 gm. to 1,500 c. c. of virus solution.	.....do.....	.....do.....	.....do.....	Do.
Pure paper-filtered virus.....	.....do.....	.....do.....	.....do.....	8 plants mosaic.
Tap water only (control).....	.....do.....	.....do.....	.....do.....	All healthy.

[a] Virus filtered clear through filter paper before solutions were made.
[b] Virus not passed through filter paper before solutions were made.

TABLE I.—*Effects of various chemicals on the infectivity of the virus of the mosaic disease of tobacco*—Continued

POTASSIUM PERMANGANATE

Concentration.	Solution prepared.	Inoculation made.	Plants used.	Results.
1 gm. to 100 c. c. of virus solution...	Aug. 25, 1915[a]	Aug. 28, 1915 (3 days later).	10.....	All healthy.
1 gm. to 200 c. c. of virus solution...	.....do.....	.....do.....	10.....	10 plants mosaic.
1 gm. to 500 c. c. of virus solution...	.....do.....	.....do.....	10.....	Do.
1 gm. to 800 c. c. of virus solution...	.....do.....	.....do.....	10.....	Do.
1 gm. to 1,000 c. c. of virus solution	.....do.....	.....do.....	10.....	9 plants mosaic.
1 gm. to 1,500 c. c. of virus solution	.....do.....	.....do.....	10.....	10 plants mosaic.
Virus without addition.....	.....do.....	.....do.....	10.....	8 plants mosaic.
Tap water only and healthy sap (control).	.....do.....	.....do.....	10.....	All healthy.

ZINC CHLORID

1 gm. to 50 c. c. of virus solution....	Oct. 12, 1915	Dec. 29, 1915 (78 days later).	10 Connecticut Broadleaf.	All healthy.
1 gm. to 100 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	Do.
1 gm. to 200 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	8 plants mosaic.
Tap water only (control).....	.....do.....	.....do.....	.....do.....	All healthy.
1 gm. to 100 c. c. of virus solution...	Feb. 21, 1916	Mar. 30, 1916 (36 days later).	.....do.....	Do.
1 gm. to 200 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	3 plants mosaic.
1 gm. to 400 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	7 plants mosaic.
1 gm. to 600 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	6 plants mosaic.
1 gm. to 800 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	8 plants mosaic.
1 gm. to 1,000 c. c. of virus solution	.....do.....	.....do.....	.....do.....	7 plants mosaic.
Virus without addition.....	.....do.....	.....do.....	.....do.....	8 plants mosaic.
Tap water only (control)	.....do.....	.....do.....	.....do.....	All healthy.

COPPER SULPHATE

1 gm. to 25 c. c. of virus solution..	Apr. 28, 1914	May 7, 1914 (9 days later).	10 Connecticut Broadleaf.	All healthy.
1 gm. to 50 c. c. of virus solution....	.....do.....	.....do.....	.....do.....	Do.
1 gm. to 100 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	Do.
1 gm. to 200 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	Do.
1 gm. to 500 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	Do.
1 gm. to 1,000 c. c. of virus solution..	.....do.....	.....do.....	.....do.....	8 plants mosaic.
Virus without addition.....	.....do.....	.....do.....	.....do.....	Do.
Tap water only and weak solution copper sulphate (control).	.....do.....	.....do.....	.....do.....	All healthy.
1 gm. to 100 c. c. of virus solution...	Nov. 17, 1915[b]	Dec. 19, 1915 (32 days later).	.....do.....	1 plant mosaic.
1 gm. to 200 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	5 plants mosaic.
1 gm. to 400 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	7 plants mosaic.
1 gm. to 600 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	9 plants mosaic.
1 gm. to 800 c. c. of virus solution...	.....do	.....do.....	.....do.....	10 plants mosaic.
1 gm. to 1,000 c. c. of virus solution.	.....do.....	.....do.....	.....do.....	8 plants mosaic.
1 gm. to 1,200 c. c. of virus solution.	.....do.....	.....do.....	.....do.....	7 plants mosaic.
1 gm. to 1,500 c. c. of virus solution.	.....do.....	.....do.....	.....do.....	10 plants mosaic.
Virus without addition.....	.....do.....	.....do.....	.....do.....	8 plants mosaic.
Tap water only (control).....	.....do.....	.....do.....	.....do.....	All healthy.

CARBOLIC ACID

1 gm. to 100 c. c. of virus solution...	Nov. 16, 1915[b]	Dec. 18, 1915 (32 days later).	10 Connecticut.	10 plants mosaic.
1 gm. to 200 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	Do.
1 gm. to 400 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	Do.
1 gm. to 600 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	Do.
1 gm. to 800 c. c. of virus solution...	.....do.....	.....do.....	.....do.....	Do.
1 gm. to 1,000 c. c. of virus solution	.....do.....	.....do.....	.....do.....	Do.
1 gm. to 1,500 c. c. of virus solution	.....do.....	.....do.....	.....do.....	Do.
Virus without addition.....	.....do.....	.....do.....	.....do.....	9 plants mosaic.
Tap water only (control).....	.....do.....	.....do.....	.....do.....	All healthy.

[a] Virus unfiltered.
[b] Virus filtered clear through filter paper before solutions were made.

TABLE I.—*Effects of various chemicals on the infectivity of the virus of the mosaic disease of tobacco*—Continued

CARBOLIC-ACID SOLUTIONS, CARBOLIC-ACID SOLUTIONS CONTAINING 1 PER CENT OF SODIUM CHLORID, AND PURE SODIUM-CHLORID SOLUTIONS

Concentration.	Solution prepared.	Inoculation made.	Plants used.	Results.
1 gm. of carbolic acid to 100 c. c. of virus solution.	Feb. 21, 1916	Mar. 15, 1916 (23 days later).	10 Connecticut Broadleaf.	9 plants mosaic.
1 gm. of carbolic acid to 200 c. c. of virus solution.	.....do.....	.....do.....	.....do.....	Do.
1 gm. of carbolic acid to 400 c. c. of virus solution.	.....do.....	.....do.....	.....do.....	Do.
1 gm. of carbolic acid to 600 c. c. of virus solution.	.....do.....	.....do.....	.....do.....	10 plants mosaic.
1 gm. of carbolic acid to 800 c. c. of virus solution.	.....do.....	.....do.....	.....do.....	Do.
1 gm. of carbolic acid to 100 c. c. of 1 per cent sodium-chlorid solutions.[b]	.....do.....	.....do.....	.....do.....	Do.
1 gm. of carbolic acid to 200 c. c. of 1 per cent sodium-chlorid solutions.	.....do.....	.....do.....	.....do.....	7 plants mosaic.
1 gm. of carbolic acid to 400 c. c. of 1 per cent sodium-chlorid solutions.	.....do.....	.....do.....	.....do.....	Do.
1 gm. of carbolic acid to 600 c. c. of 1 per cent sodium-chlorid solutions.	.....do.....	.....do.....	.....do.....	9 plants mosaic.
1 gm. of carbolic acid to 800 c. c. of 1 per cent sodium-chlorid solutions.	.....do.....	.....do.....	.....do.....	7 plants mosaic.
1 gm. of sodium chlorid to 50 c. c. of virus solution.	.....do.....	.....do.....	.....do.....	5 plants mosaic.
1 gm. of sodium chlorid to 100 c. c. of virus solution.	.....do.....	.....do.....	.....do.....	8 plants mosaic.
1 gm. of sodium chlorid to 400 c. c. of virus solution.	.....do.....	.....do.....	.....do.....	9 plants mosaic.
Virus without addition	.....do.....	.....do.....	.....do.....	8 plants mosaic.
Tap water only (control)	.....do.....	.....do.....	.....do.....	All healthy.

CRÉOLIN (PEARSON) SOLUTIONS

1 gm. to 50 c. c. of virus solution	Mar. 2, 1916	Mar. 29, 1916 (27 days later).	10 Connecticut Broadleaf.	3 plants mosaic.
1 gm. to 100 c. c. of virus solution	.....do.....	.....do.....	.....do.....	7 plants mosaic.
1 gm. to 200 c. c. of virus solution	.....do.....	.....do.....	.....do.....	10 plants mosaic.
1 gm. to 400 c. c. of virus solution	.....do.....	.....do.....	.....do.....	Do.
Virus without addition	.....do.....	.....do.....	.....do.....	Do.
Tap water only (control)	.....do.....	.....do.....	.....do.....	All healthy.

CRESOL[a] SOLUTIONS

1 gm. to 100 c. c. of virus solution	Mar. 10, 1916	Mar. 29, 1916 (19 days later).	10 Connecticut Broadleaf.	10 plants mosaic.
1 gm. to 200 c. c. of virus solution	.....do.....	.....do.....	.....do.....	9 plants mosaic.
1 gm. to 400 c. c. of virus solution	.....do.....	.....do.....	.....do.....	10 plants mosaic.
1 gm. to 600 c. c. of virus solution	.....do.....	.....do.....	.....do.....	Do.
Tap water only (control)	.....do.....	.....do.....	.....do.....	All healthy.

CARBOLIC-ACID SOLUTIONS AND PHENOCO[b] SOLUTIONS

1 gm. of carbolic acid to 50 c. c. of virus solution.	Feb. 20, 1917[c]	Mar. 7, 1917 (15 days later).	10 Connecticut Broadleaf.	10 plants mosaic.
1 gm. of carbolic acid to 100 c. c. of virus solution.	.....do.....	.....do.....	.....do.....	Do.
1 gm. of carbolic acid to 200 c. c. of virus solution.	.....do.....	.....do.....	.....do.....	Do.
1 gm. of carbolic acid to 400 c. c. of virus solution.	.....do.....	.....do.....	.....do.....	Do.
1 gm. of phenoco to 100 c. c. of virus solution.	.....do.....	.....do.....	.....do.....	7 plants mosaic.
1 gm. of phenoco to 200 c. c. of virus solution.	.....do.....	.....do.....	.....do.....	9 plants mosaic.
1 gm. of phenoco to 400 c. c. of virus solution.	.....do.....	.....do.....	.....do.....	Do.

[a] A mixture of the three isomeric cresols.
[b] Phenoco is a commercial disinfectant composed of emulsified phenol homologues and neutral tar oils.
[c] Prepared with fresh, unfiltered virus.

TABLE I.—*Effects of various chemicals on the infectivity of the virus of the mosaic disease of tobacco*—Continued

CARBOLIC-ACID SOLUTIONS AND PHENOCO SOLUTIONS—continued

Concentration.	Solution prepared.	Inoculation made.	Plants used.	Results.
1 gm. of phenoco to 600 c. c. of virus solution.	Feb. 20, 1917	Mar. 7, 1917 (15 days later).	10 Connecticut Broadleaf.	10 plants mosaic.
1 gm. of phenoco to 800 c. c. of virus solution.	do	do	do	Do.
Virus without addition	do	do	do	7 plants mosaic.
Tap water only (control)	do	do	do	All healthy.
1 gm. of carbolic acid to 50 c. c. of virus solution.	do	Mar. 27, 1917 (35 days later).	do	9 plants mosaic.
1 gm. of carbolic acid to 100 c. c. of virus solution.	do	do	do	10 plants mosaic.
1 gm. of phenoco to 100 c. c. of virus solution.	do	do	do	Do.
1 gm. of phenoco to 200 c. c. of virus solution.	do	do	do	8 plants mosaic.
Virus without addition	do	do	do	10 plants mosaic.
Tap water only (control)	do	do	do	All healthy.
1 gm. of carbolic acid to 50 c. c. of virus solution.	do	Nov. 11, 1917 (364 days later).	do	4 plants mosaic.
1 gm. of carbolic acid to 100 c. c. of virus solution.	do	do	do	7 plants mosaic.
1 gm. of carbolic acid to 200 c. c. of virus solution.	do	do	do	10 plants mosaic.
1 gm. of carbolic acid to 400 c. c. of virus solution.	do	do	do	8 plants mosaic.
1 gm. of phenoco to 100 c. c. of virus solution.	do	do	do	Do.
1 gm. of phenoco to 200 c. c. of virus solution.	do	do	do	9 plants mosaic.
1 gm. of phenoco to 400 c. c. of virus solution.	do	do	do	10 plants mosaic.
1 gm. of phenoco to 600 c. c. of virus solution.	do	do	do	Do.
1 gm. of phenoco to 800 c. c. of virus solution.	do	do	do	9 plants mosaic.
Virus without addition	do	do	do	Do.
Tap water only (control)	do	do	do	All healthy.

ACETONE

Virus in 10 per cent acetone	Oct. 6, 1915	Dec. 22, 1915 (77 days later).	10 Connecticut Broadleaf.	9 plants mosaic.
Virus in 20 per cent acetone	do	do	do	4 plants mosaic.
Virus in 30 per cent acetone	do	do	do	9 plants mosaic.
Virus in 40 per cent acetone	do	do	do	8 plants mosaic.
Virus in 50 per cent acetone	do	do	do	All healthy.
Tap water only (control)	do	do	do	Do.

The cresols are relatively more powerful germicides than carbolic acid. Behring[1] has shown that for certain vegetative forms cresol may have 4 times and creolin 10 times the germicidal power of carbolic acid. The relative differences in the germicidal action of carbolic acid, cresol, and creolin are not apparent in their effects upon the infective principle of the mosaic disease of tobacco under the conditions of the writer's experiments.

In its germicidal action carbolic acid is supposed to act as a molecule, and not by ionization; and the addition of salt greatly increases its germicidal powers. In the time during which it has been allowed to act in the above experiments, there appears to be no appreciable difference

[1] BEHRING, V. BEKÄMPFUNG DER INFECTIONSKRANKHEITEN. . . . 251 p. Leipzig, 1894.

between the carbolic-acid solution and the carbolic-acid and salt solutions in their effects upon the infective principle of the virus.

Phenoco has been shown by Anderson and McClintic [1] to have a phenol coefficient of 15 when tested upon the typhoid bacillus without organic matter, and a coefficient of 9.86 when tested in the presence of organic matter. Although this preparation appears to be a much more powerful germicide than carbolic acid when tested upon the typhoid bacillus, no especially marked differences are shown when tested upon the infective principle of the mosaic disease of tobacco.

The virus of the mosaic disease very quickly loses its power to infect healthy plants when preserved in the higher strengths of ethyl alcohol. In the following tests the expressed sap was filtered through filter paper and mixed with different proportions, by volume, of absolute alcohol. In the process of obtaining the different strengths, the virus at most was diluted but a few times. This slight dilution is without significance since earlier experiments have shown that a dilution of 1,000 times with water does not materially reduce the power to infect. Throughout these tests the plants in each series were kept under observation for a considerable period after the first appearance of symptoms of the disease. There was no noticeable difference, however, in the inoculation period at any time. At present there is no means of knowing whether or not it is possible for the virus of the mosaic disease to retain a certain degree of viability after the power to infect healthy plants has been lost. The results of any germicidal tests are influenced by the concentration of the germicide and the time during which it acts. It is evident that both factors have had more or less influence upon the results obtained for the alcoholic tests presented here. The effect of different concentrations of alcohol upon the infectivity of the virus is given in Table II.

TABLE II.—*Effect of various concentrations of alcohol upon the infectivity of the virus of the mosaic disease*

VIRUS A (PRESERVED IN 25–80 PER CENT ALCOHOL ON FEBRUARY 27, 1914)

Date of inoculation.	Number of plants.	Variety.	Treatment.	Effect.
Apr. 1.....	10	Connecticut Broadleaf.	Virus A kept in 50 per cent alcohol 33 days.	1 mosaic.
Do.....	10	.....do.....	Untreated virus A kept 33 days.	8 mosaic.
Apr. 2.....	10	.....do.....	Virus A kept in 25 per cent alcohol 34 days.	7 mosaic.
Apr. 3.....	20	.....do.....	Virus A kept in 50 per cent alcohol 35 days.	4 mosaic.
Do.....	10	.....do.....	Virus A kept in 80 per cent alcohol 35 days.	All healthy.
Do.....	20	.....do.....	Untreated virus A kept 35 days.	14 mosaic.

[1] ANDERSON, J. F., and MCCLINTIC, T. B. METHOD OF STANDARDIZING DISINFECTANTS WITH AND WITHOUT ORGANIC MATTER. *In* Pub. Health and Mar. Hosp. Serv. U. S. Hyg. Lab. Bul. 82, p. 1–34. 1912.

TABLE II.—*Effect of various concentrations of alcohol upon the infectivity of the virus of the mosaic disease*—Continued

VIRUS A (PRESERVED IN 25–80 PER CENT ALCOHOL ON FEBRUARY 27, 1914)—contd.

Date of inoculation.	Number of plants.	Variety.	Treatment.	Effect.
Apr. 4	10	Connecticut Broadleaf.	Virus A kept in 50 per cent alcohol 36 days.	1 mosaic.
Do	10	do	Thin paste obtained from dried and ground leaves from which virus A had been expressed, kept 36 days.	5 mosaic.
Do	10	do	Healthy juice and tap water (control).	All healthy.
Do	20	*N. rustica*	Virus A kept in 50 per cent alcohol 36 days.	Do.
Do	10	do	Virus A kept in 80 per cent alcohol 36 days.	Do.
Do	10	do	Virus A, untreated, kept 36 days.	4 mosaic.
Do	10	do	Healthy juice and tap water (control).	All healthy.
Inoculations made 40 or 41 days later:				
Apr. 8	10	Connecticut Broadleaf.	Virus A kept in 25 per cent alcohol 40 days.	5 mosaic.
Do	30	do	Virus A kept in 50 per cent alcohol 40 days.	All healthy.
Do	10	do	Virus A kept in 80 per cent alcohol 40 days.	Do.
Do	20	do	Healthy juice and tap water (control).	Do.
Apr. 9	10	do	Virus A kept in 50 per cent alcohol 41 days.	Do.
Inoculations made 55 days later:				
Apr. 23	10	do	Virus A kept in 25 per cent alcohol 55 days.	1 mosaic.
Do	10	do	Virus A kept in 50 per cent alcohol 55 days.	All healthy.
Do	10	do	Virus A kept in 80 per cent alcohol 55 days.	Do.
Do	10	do	Virus A, untreated, kept 55 days.	3 mosaic.
Do	10	do	Healthy juice, fresh	All healthy.
Inoculations made 56 days later:				
Apr. 24	10	do	Virus A kept in 25 per cent alcohol 56 days.	5 mosaic.
Do	30	do	Virus A kept in 50 per cent alcohol 56 days.	All healthy.
Do	10	do	Virus A kept in 80 per cent alcohol 56 days.	Do.
Do	10	do	Virus A, untreated, kept 56 days.	6 mosaic.
Do	10	do	Healthy juice and tap water.	All healthy.

TABLE II.—*Effect of various concentrations of alcohol upon the infectivity of the virus of the mosaic disease*—Continued

VIRUS A (PRESERVED IN 25–80 PER CENT ALCOHOL ON FEBRUARY 27, 1914)—contd.

Date of inoculation.	Number of plants.	Variety.	Treatment.	Effect.
Inoculations made 68 days later:				
May 6.....	10	Maryland Mammoth.	Virus A kept in 25 per cent alcohol 68 days.	6 mosaic.
Do.....	10	.....do.....	Virus A, untreated, kept 68 days.	10 mosaic.
Do.....	10	.....do.....	Healthy juice, fresh.....	All healthy.
Do.....	10	.....do.....	Alcohol and tap-water solution.	Do.
Inoculations made 91 days later:				
May 29.....	10	.....do.....	Virus A kept in 25 per cent alcohol 91 days.	8 mosaic.
Do.....	10	.....do.....	Virus A, untreated, kept 91 days.	10 mosaic.
Do.....	10	.....do.....	Healthy juice, fresh.....	All healthy.
Inoculations made 199 days later:				
Sept. 14.....	10	Connecticut Broadleaf.	Virus A kept in 25 per cent alcohol 199 days.	7 mosaic.
Do.....	10	.....do.....	Virus A, untreated, kept 199 days.	9 mosaic.
Do.....	10	.....do.....	Healthy juice, fresh.....	All healthy.

VIRUS B (PRESERVED IN 95 PER CENT ALCOHOL ON APRIL 8, 1914)

Apr. 23.....	10	Connecticut Broadleaf.	Virus B, untreated, kept 15 days.	4 mosaic.
Apr. 24.....	10	.....do.....	Virus B kept in 95 per cent alcohol 16 days.	All healthy.
Do.....	10	.....do.....	Virus B, untreated, kept 16 days.	6 mosaic.
Do.....	10	.....do.....	Healthy juice, fresh.....	All healthy.

VIRUS C (PRESERVED IN 25–90 PER CENT ALCOHOL ON APRIL 27, 1914)

May 2.....	10	Maryland Mammoth.	Virus C kept in 25 per cent alcohol 5 days.	9 mosaic.
Do.....	10	.....do.....	Virus C kept in 30 per cent alcohol 5 days.	7 mosaic.
Do.....	10	.....do.....	Virus C kept in 35 per cent alcohol 5 days.	9 mosaic.
Do.....	10	.....do.....	Virus C kept in 40 per cent alcohol 5 days.	5 mosaic.
Do.....	10	.....do.....	Virus C kept in 45 per cent alcohol 5 days.	6 mosaic.
Do.....	10	.....do.....	Virus C kept in 50 per cent alcohol 5 days.	2 mosaic.
Do.....	10	.....do.....	Virus C kept in 55 per cent alcohol 5 days.	All healthy.
Do.....	10	.....do.....	Virus C kept in 60 per cent alcohol 5 days.	Do.
Do.....	10	.....do.....	Virus C kept in 70 per cent alcohol 5 days.	Do.

TABLE II.—*Effect of various concentrations of alcohol upon the infectivity of the virus of the mosaic disease*—Continued

VIRUS C (PRESERVED IN 25–90 PER CENT ALCOHOL ON APRIL 27, 1914)—continued

Date of inoculation.	Number of plants.	Variety.	Treatment.	Effect.
May 2.....	10	Maryland Mammoth.	Virus C kept in 80 per cent alcohol 5 days.	All healthy.
Do.....	10	.....do.....	Virus C kept in 90 per cent alcohol 5 days.	Do.
Do.....	20	.....do.....	Virus C, untreated, kept 5 days.	12 mosaic.
Do.....	10	.....do.....	Healthy juice, fresh.....	All healthy.
Inoculations made 21 days later:				
May 18.....	10	.....do.....	Virus C kept in 25 per cent alcohol 21 days.	9 mosaic.
Do.....	10	.....do.....	Virus C kept in 35 per cent 21 days.	Do.
Do.....	10	.....do.....	Virus C kept in 40 per cent alcohol 21 days.	7 mosaic.
Do.....	10	.....do.....	Virus C kept in 45 per cent alcohol 21 days.	4 mosaic.
Do.....	10	.....do.....	Virus C kept in 50 per cent alcohol 21 days.	All healthy.
Do.....	10	.....do.....	Virus C kept in 55 per cent alcohol 21 days.	Do.
Do.....	10	.....do.....	Virus C untreated, kept 21 days.	10 mosaic.
Do.....	10	.....do.....	Healthy juice and tap water.	All healthy.
Inoculations made 140 days later:				
Sept. 14.....	10	Connecticut Broadleaf.	Virus C kept in 25 per cent alcohol 140 days.	10 mosaic.
Do.....	10	.....do.....	Virus C kept in 30 per cent alcohol 140 days.	9 mosaic.
Do.....	10	.....do.....	Virus C kept in 35 per cent alcohol 140 days.	10 mosaic.
Do.....	10	.....do.....	Virus C kept in 40 per cent alcohol 140 days.	2 mosaic.
Do.....	10	.....do.....	Virus C kept in 45 per cent alcohol 140 days.	3 mosaic.
Do.....	10	.....do.....	Virus C kept in 50 per cent alcohol 140 days.	All healthy.
Do.....	10	.....do.....	Virus C, untreated, kept 140 days.	8 mosaic.
Do.....	10	.....do.....	Healthy juice, fresh.....	All healthy.
VIRUS D (PRESERVED IN 80 PER CENT ALCOHOL ON MAY 21, 1914)				
May 21.....	10	Maryland Mammoth.	Virus D kept in 80 per cent alcohol ½ hour.	All healthy.
Do.....	10	.....do.....	Virus D kept in 80 per cent alcohol 1 hour.	Do.
Do.....	10	.....do.....	Virus D kept in 80 per cent alcohol 2 hours.	Do.
Do.....	10	.....do.....	Virus D kept in 80 per cent alcohol 3 hours.	Do.
Do.....	10	.....do.....	Virus D kept in 80 per cent alcohol 4 hours.	Do.

TABLE II.—*Effect of various concentrations of alcohol upon the infectivity of the virus of the mosaic disease*—Continued

VIRUS D (PRESERVED IN 80 PER CENT ALCOHOL ON MAY 21, 1914)—continued

Date of inoculation.	Number of plants.	Variety.	Treatment.	Effect.
May 22.....	10	Maryland Mammoth.	Virus D kept in 80 per cent alcohol 24 hours.	All healthy.
Do.....	10	.....do.....	Virus D kept in 80 per cent alcohol 28 hours.	Do.
Do.....	10	.....do.....	Virus D untreated.....	9 mosaic.

VIRUS E (PRESERVED IN 80 PER CENT ALCOHOL ON MAY 27, 1914)

May 27.....	10	Maryland Mammoth.	Virus E kept in 80 per cent alcohol 2 minutes.	1 mosaic.
Do.....	10	.....do.....	Virus E kept in 80 per cent alcohol 10 minutes.	3 mosaic.
Do.....	10	.....do.....	Virus E kept in 80 per cent alcohol 30 minutes.	1 mosaic.
Do.....	10	.....do.....	Virus E kept in 80 per cent alcohol 60 minutes.	All healthy.
Do.....	10	.....do.....	Virus E untreated.....	10 mosaic.
Do.....	10	.....do.....	Healthy juice.....	All healthy.

VIRUS F (PRESERVED IN 25–60 PER CENT ALCOHOL ON MAY 23, 1914)

May 29.....	10	Maryland Mammoth.	Virus F kept in 25 per cent alcohol 6 days.	7 mosaic.
Do.....	10	.....do.....	Virus F kept in 30 per cent alcohol 6 days.	10 mosaic.
Do.....	10	.....do.....	Virus F kept in 35 per cent alcohol 6 days.	Do.
Do.....	10	.....do.....	Virus F kept in 40 per cent alcohol 6 days.	9 mosaic.
Do.....	10	.....do.....	Virus F kept in 45 per cent alcohol 6 days.	Do.
Do.....	10	.....do.....	Virus F kept in 50 per cent alcohol 6 days.	3 mosaic.
Do.....	10	.....do.....	Virus F kept in 60 per cent alcohol 6 days.	All healthy.
Do.....	10	.....do.....	Virus F, untreated, kept 6 days.	10 mosaic.
Do.....	10	.....do.....	Fresh, healthy juice.....	All healthy.

VIRUS G (PRESERVED IN 80 PER CENT ALCOHOL ON MAY 31, 1914)

May 31.....	10	Maryland Mammoth.	Virus G kept in 80 per cent alcohol 2 minutes.	4 mosaic.
Do.....	10	.....do.....	Virus G kept in 80 per cent alcohol 5 minutes.	3 mosaic.
Do.....	10	.....do.....	Virus G untreated.....	10 mosaic.
Do.....	10	.....do.....	Healthy juice.....	All healthy.

TABLE II.—*Effect of various concentrations of alcohol upon the infectivity of the virus of the mosaic disease*—Continued

VIRUS H (PRESERVED IN 80 PER CENT ALCOHOL ON MAY 31, 1914)

Date of inoculation.	Number of plants.	Variety.	Treatment.	Effect.
May 31.....	10	Maryland Mammoth.	Virus H kept in 80 per cent alcohol 2 minutes.	4 mosaic.
Do.....	10	.....do.....	Virus H untreated.....	10 mosaic.
Do.....	10	.....do.....	Healthy juice and tap water.	All healthy.

VIRUS I (PRESERVED IN 40–75 PER CENT ALCOHOL ON FEBRUARY 12, 1915)

March 3.....	10	Connecticut Broadleaf.	Virus I kept in 40 per cent alcohol 19 days.	10 mosaic.
Do.....	10	.....do.....	Virus I kept in 50 per cent alcohol 19 days.	5 mosaic.
Do.....	10	.....do.....	Virus I kept in 60 per cent alcohol 19 days.	All healthy.
Do.....	10	.....do.....	Virus I kept in 75 per cent alcohol 19 days.	Do.
Do.....	10	.....do.....	Virus I untreated.....	6 mosaic.
Do.....	10	.....do.....	Fresh, healthy juice and tap water.	All healthy.

The results of inoculations with alcoholic solutions of virus A show that the virus of mosaic was not affected by 25 per cent alcohol. Its viability, or at least its power to infect, appeared to be unchanged 199 days later. The 50 per cent alcohol solutions were infective 35 to 36 days after preparation, although it is evident that the power to infect had fallen considerably below that of the original virus. Inoculations made with these strengths 40 to 41 days after preparation indicate that the virus in 50 per cent alcohol had become innocuous to healthy plants.

The tests with alcoholic solutions of virus C show very clearly that the virus of mosaic can not long retain its infectious properties in alcohol stronger than 50 to 55 per cent. Five days after preparation all solutions containing 55 per cent or more of alcohol became innocuous. The virus gives evidence of lessening virulence in the 50 per cent alcoholic solution. The power to produce infection appears to have been completely lost by the 50 per cent solution 21 days after preparation. Tests of these solutions 140 days later indicate that the 45 per cent solution was still infectious to healthy plants.

Practically the same results are shown with alcoholic solutions of virus F. All solutions up to 50 per cent were infective 6 days after preparation. As in preceding tests, the 50 per cent solution again gave evidence of decrease in the power to produce mosaic.

Tests with virus D indicate that the virus of the mosaic disease preserved in 80 per cent alcohol became innocuous in less than half an hour.

The virus does not appear to lose instantly its power to produce infection. In a few minutes, however, the virus appears to lose much of its original power to produce infection.

Heintzel [1] treated fresh, mosaic-diseased leaves with 50 per cent alcohol and used the filtered extract for inoculations. This extract produced the disease in healthy plants. In this test it is evident that the water contained in the fresh leaves would reduce the alcohol below the 50 per cent strength used. It also appears that the extract was used at once for inoculation. It would be expected that these extracts would produce infection, since the writer's experiments indicate that the virus may retain its infectivity for a number of days in alcoholic solutions below a 50 per cent strength. Heintzel also treated fresh, unfiltered sap with strong alcohol and filtered out and dried the precipitate. This also produced infection in healthy plants. Since no exact data are given as to the time of treatment and the amount of sap and alcohol used, one can not interpret these results without further details of the methods used.

Koning [2] treated the sap of mosaic-diseased plants with alcohol several times, pouring off the clear, supernatant solution and renewing the alcohol each time. The precipitate which was finally used for inoculation had lost its infectious properties, as would be expected from the writer's results with the higher alcoholic concentrations.

Chloral hydrate in concentrations of 1 in 10, 1 in 20, 1 in 200, 1 in 500, 1 in 800, and 1 in 1,000 parts of virus solution did not appreciably affect the infectivity of the virus after 17 days' treatment.

Tannic acid in concentrations of 1 in 20 and 1 in 50 parts of virus solution killed the infectivity of the virus, as these were no longer infectious after 5 days' treatment. In concentrations of 1 in 100 and 1 in 200 the virus had almost entirely lost its infective properties in the same period. Lecithin had no appreciable effect upon the infectivity of the virus after 5 days in 1, 2, 5, 10, and 20 per cent strengths.

Benzoate of soda in concentrations of 1 in 25, 1 in 50, and 1 in 500 parts of virus solution had apparently not changed the infectivity of the virus after 48 days' treatment. In concentrations of 1 in 100 and 1 in 200 parts of virus solution the virus had not entirely lost its infectivity after 101 days' treatment, although it had been greatly weakened.

Quinine bisulphate in concentrations of 1 in 25, 1 in 500, and 1 in 1,000 parts of virus solution did not noticeably affect the infectivity of the virus after 19 days' treatment.

Sodium taurocholate in 1 and 2 per cent strengths did not destroy the infectivity of the virus after 5 days' treatment. In 5 and 10 per cent strengths the virus had completely lost its infectivity in the same period.

[1] HEINTZEL, K. G. E. CONTAGIÖSE PFLANZENKRANKHEITEN OHNE MICROBEN, UNTER BESONDERER BERÜCKSICHTIGUNG DER MOSAIKKRANKHEIT DER TABAKSBLÄTTER. 46 p., pl. Erlangen, 1900. (Inaugural Dissertation.)

[2] KONING, C. J. DER TABAK. STUDIEN ÜBER SEINE KULTUR UND BIOLOGIE. 86 p., 15 fig. Amsterdam, Leipzig, 1900.

Saponin in 1, 2, 5, 10, and 15 per cent strengths was tested after three days' treatment. The infectivity of the virus was not entirely lost in any of these strengths, but only one or two cases of the mosaic disease resulted in each test, showing that the virus had been greatly weakened in this period.

Virus treated with naphthalene crystals in excess was highly infectious when tested 16 days later.

Virus treated with camphor in excess was highly infectious when tested six days later.

Virus treated with thymol in excess was highly infectious when tested nine days later.

Antiformin (Eimer & Amend, 1916) in a 1 per cent strength had greatly weakened the virus after three days' treatment, while 5 and 10 per cent strengths had destroyed the infectivity in the same time.

Taka-diastase in excess did not appreciably affect the infectivity of the virus after 17 days' treatment.

Formaldehyde in the concentration of 1 part in 100 parts of virus solution was used for inoculation 10 minutes, 1 hour, and 2 hours after being prepared. The infectivity of the virus was greatly weakened, but not wholly destroyed even after 2 hours' treatment. A concentration of 1 in 100 parts of virus solution had entirely lost its infectivity when tested 10 hours later. In other tests formaldehyde in concentrations of 1 in 200, 1 in 400, 1 in 600, 1 in 800, and 1 in 1,000 parts of virus solution were used for inoculation 18 hours after preparation. The results were as follows:

1 part formaldehyde in 200 parts virus solution	All healthy.
1 part formaldehyde in 400 parts virus solution	2 plants mosaic.
1 part formaldehyde in 600 parts virus solution	3 plants mosaic.
1 part formaldehyde in 800 parts virus solution	7 plants mosaic.
1 part formaldehyde in 1,000 parts virus solution	9 plants mosaic.
Virus untreated	8 plants mosaic.
Tap water only (control)	All healthy.

A 4 per cent formaldehyde solution of virus was prepared and inoculated 10 minutes later and gave three plants mosaic. Inoculations made 20 minutes later showed that all infective properties had been destroyed. The original virus gave 10 plants mosaic, and all controls with tap water remained healthy.

These experiments indicate that the virus of the mosaic disease of tobacco is quickly rendered innocuous in a 4 per cent strength of formaldehyde. This strength has been used by the writer to sterilize pots, which were immersed in the solution from 30 minutes to 1 hour before they were taken out and washed.

Glycerin appears to affect the infectivity of the virus of the mosaic disease of tobacco only very slowly in the lower concentrations. Very strong concentrations appear to weaken its infectivity noticeably in some

instances. Solutions prepared and used for inoculation seven days later gave the following results, 10 Connecticut Broadleaf plants being used in each test:

Virus in 20 per cent glycerin strength	7 plants mosaic.
Virus in 50 per cent glycerin strength	5 plants mosaic.
Virus in 72 per cent glycerin strength	4 plants mosaic.
Virus in 80 per cent glycerin strength	7 plants mosaic.
Virus in 90 per cent glycerin strength	2 plants mosaic.
Virus untreated	9 plants mosaic.
Tap water only (control)	All healthy.

In another test solutions used nine days later gave the following results:

Virus in 10 per cent glycerin strength	5 plants mosaic.
Virus in 25 per cent glycerin strength	2 plants mosaic.
Virus in 50 per cent glycerin strength	4 plants mosaic.
Virus in 75 per cent glycerin strength	All healthy.
Virus in 90 per cent glycerin strength	1 plant mosaic.
Virus untreated	8 plants mosaic.
Tap water only (control)	All healthy.

In the higher concentrations of glycerin—that is, 50, 70, 80, and 90 per cent—the virus may show very weak infectious properties for a long time. In some tests the virus showed very weak infectious properties in 80 and 90 per cent strength glycerin after 35 days' treatment. In other tests, made with different lots of virus, these strengths appeared to kill the infective principle of the virus in much shorter periods.

Koning's [1] experiments indicate that, after long periods of treatment, glycerin destroyed the virus. In one experiment fresh, finely cut portions of mosaic-diseased leaves, which were allowed to stand in glycerin all winter, lost their infectivity.

Heintzel [2] states that glycerin did not affect the infectivity of the virus. His experiments, however, can not be considered final, as he added only a few drops of glycerin to the fresh sap. This author does not state how much sap was used, nor give the time of the treatment. His glycerin solutions appeared to be very dilute, and it would appear that they were used for inoculation at once. As a result, glycerin in his tests did not noticeably affect the infectivity of the virus.

The virus of the mosaic disease of tobacco when mixed with talc, kaolin, or soil frequently loses its infectious properties more quickly than when the virus is merely bottled without the addition of any preservative. In one experiment 25 c. c. of virus were added to about equal volumes of soil, of talc, and of kaolin. After the virus had been added and mixed thoroughly, each lot of material was in the condition of a stiff paste. Forty-three days later each lot of material was thoroughly extracted with 70 c. c. of distilled water, and the solutions were inoculated into lots of 10 plants each. The kaolin and the talc preparations

[1] KONING, C. J. op. cit. [2] HEINTZEL, G. E. op. cit.

possessed no infectious properties whatever, while the soil preparation and the original bottled virus were still infectious.

In an additional test 50 c. c. of virus were mixed with 72 gm. of kaolin, U. S. P. Thirty-two days later this material still possessed infectious properties. When tested again, 61 days later, it no longer possessed them.

In a test carried out in March, 1917, 200 gms. of finely screened greenhouse soil were mixed to a stiff paste with 50 c. c. of freshly extracted sap obtained from mosaic plants. One hundred gms. of talc, U. S. P., were mixed with 75 c. c. of fresh virus from the same source, and 100 gm. of finely ground, pure quartz sand were mixed with 25 c. c. of virus. A portion of the original virus was set aside in a bottle. The sand, soil, and talc pastes were kept in glass jars and covered with a sheet of heavy paper tied over the mouth. In November, 231 days later, inoculation tests were made with this virus. The talc and soil preparations appeared to have completely lost their infectious properties, but the sand preparation and the original, bottled virus were highly infectious.

Koning's [1] experiments led him to believe that the soil in some manner destroyed the infective principle of the mosaic disease. Heintzel [2] was also of the opinion that the soil weakened the infectious principle of the disease.

SUMMARY

Nitric and hydrochloric acids had little effect upon the infectivity of the virus, except in concentrations approaching 1 gm. in 50 to 100 c. c. of virus solution. Phosphoric, citric, and acetic acids were without effect, except in concentrations approaching 1 gm. in 20 to 50 c. c. of virus solution.

The virus was more sensitive to the effect of sodium hydroxid than to sodium carbonate.

Manganese sulphate, sodium chlorid, aluminium sulphate, lithium nitrate, sodium nitrate, lead nitrate, and silver nitrate had little effect upon the infectivity of the virus.

Mercuric chlorid affected the virus but little.

Potassium permanganate and zinc chlorid affected the infectivity of the virus only in concentrations stronger than 1 gm. in 100 c. c. of virus solution.

Under certain conditions the copper sulphate has shown itself rather toxic to the infective principle.

Carbolic acid, Creolin, cresol, and Phenoco have affected the infective principle but little under the conditions of the experiments, and there appears to be no appreciable difference in their effects. Phenoco, although having a phenol coefficient of 15 when tested upon the typhoid

[1] KONING, C. J. op. cit. [2] HEINTZEL, G. E. op. cit.

bacillus, according to Anderson and and McClintic,[1] does not appear to be stronger than carbolic acid or cresol in its effect upon the infective principle of the mosaic disease of tobacco.

Acetone destroys the infective principle of the mosaic disease much less readily than ethyl alcohol. The infective principle is destroyed rather quickly in alcohol stronger than 50 to 55 per cent. Eighty per cent strengths killed the virus in less than half an hour.

Chloral hydrate in the writer's experiments did not appreciably affect the infectivity of the virus. Benzoate of soda and quinine bisulphate affected the virus but little under the conditions of the experiments. Tannic acid appeared to be somewhat less effective than sodium taurocholate or saponin. Naphthalene crystals, camphor, and thymol had no appreciable effect.

Formaldehyde in a 4 per cent strength destroyed the infective principle very quickly. Glycerin, except in very strong concentrations, affects the virus but little.

When mixed with talc, kaolin, or soil, the virus frequently loses its nfectious properties more quickly than when merely bottled without the addition of any preservative.

[1] Anderson, J. F., and McClintic, T. B. op. cit.

A STUDY OF THE PHYSICAL CHANGES IN FEED RESIDUES WHICH TAKE PLACE IN CATTLE DURING DIGESTION

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INTRODUCTION

The data reported in this paper were obtained by the senior writer and others at the Georgia Agricultural Experiment Station in making studies on the rate of passage of feed residues through the steer and its influence on digestion coefficients.[1] Most of the investigations on digestion in cattle have been made from a chemical rather than from a physical standpoint, yet the importance of the part physics plays has been frequently referred to.[2] This report covers the physical changes which took place in the rations studied during the process of digestion and covers these changes with relation to the several organs and steps in digestion rather than the process of digestion as a whole.

METHOD OF CONDUCTING THE INVESTIGATION

ANIMALS.—The animals used in this work were high-grade 3-year-old Tennessee-bred Shorthorn steers. They had been used in the nutrition studies[3] in the winter of 1915–16, after which they were killed late in the spring of 1916 when slaughter tests were made.

FEEDS.—Corn silage and cottonseed meal especially prepared were the feeds used in these experiments. The corn silage was prepared by having the ears pulled off before it went into the silo. While this resulted in a higher percentage of fiber and a lower percentage of nitrogen-free extracts and other nutrients, it had the desired mechanical properties. Silage that would not pass through a 2-mm. screen was wanted. The meal was of the best quality. It was prepared by first passing it through a 15-mesh screen and later through a 20-mesh screen. This removed all except the

[1] EWING, P. V., and SMITH, F. H. A STUDY OF THE RATE OF PASSAGE OF FOOD RESIDUES THROUGH THE STEER AND ITS INFLUENCE ON DIGESTION COEFFICIENTS. *In* Jour. Agr. Research, 10, no. 2, p. 55–63. 1917.

[2] SMITH, R. M. THE PHYSIOLOGY OF THE DOMESTIC ANIMALS. p. 337. Philadelphia, 1889.

[3] EWING, P. V., WELLS, C. A., and SMITH, F. H. THE ASSOCIATIVE DIGESTIBILITY OF CORN SILAGE AND COTTONSEED MEAL IN STEER RATIONS. Pt. 2. Ga. Agr. Exp. Sta. Bul. 125, p. 149–164, 1 fig. 1917.

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most finely ground hulls, the result being a poor grade of cottonseed flour. Even on soaking or after passing through a steer no particles were over 2 mm. in size. The composition of these feeds is given in Table I.

TABLE I.—*Average analyses of feeds used*

Feed.	Dry matter.	Ash.	Nitrogen.	Crude fiber.	Nitrogen-free extract.	Fat.
Silage	25.65	1.62	0.157	9.82	12.80	0.43
Cottonseed meal	90.12	5.57	6.220	5.70	32.24	7.73

RATIONS.—The composition of the rations fed prior to making the slaughter tests is given in Table II. These particular rations were used because of the bearing they had on the previously conducted digestion experiments. In regard to the rations used it should be noted from the table that the rations were so planned that of the two actual rations fed—that is, those rations in which both feeds appeared—we have actual qualitative and quantative slaughter tests of the component parts of the rations.

WEIGHING AND SAMPLING OF FEEDS.—A sample of the silage was taken from each feed and placed in an air-tight specimen jar, to which a sufficient amount of toluene was added to preserve properly the sample. This was kept in a refrigerator at a temperature of about 4° to 6° C., after which it was weighed, air-dried, reweighed, ground, and sampled for chemical analysis. Samples of the cottonseed meal were collected during the feeding period and analyzed at the close of the test.

FEEDING PERIOD.—In every case the minimum feeding period prior to slaughter was 18 days, which had been found from previous work to be sufficient to clear satisfactorily the alimentary tract of residues from previous feeds.

SLAUGHTER TESTS.—The slaughter tests upon which this work is based were made with six steers, as shown in Table II, which gives the numbers, dates of slaughter, rations fed, and other data. Prior to slaughter these steers had been fed regularly night and morning on the test rations. They were killed, by shooting, at 12.30 p. m., 30 minutes after consuming a half-feed, at which time they were considered as approximating the nearest normal condition, so far as the contents of the entire alimentary tract and the several organs were concerned. The esophagus was then exposed and tied, as was the rectum. As rapidly as possible the several organs were then secured so as to prevent passing of residues from one organ to another. Afterwards the contents of each organ were weighed, dried, and sampled; physical analyses were then made separately (Table II).

TABLE II.—*Summary of tests made in 1916*

Steer No.	Date.	Weight of steer.	Percentage composition of ration.		Daily feeds.		Average daily dry matter in—		Average time in passage through steer.
			Silage.	Cotton-seed meal.	Silage.	Cotton-seed meal	Feeds.	Feces.	
		Kgm.			*Kgm.*	*Kgm.*	*Kgm.*	*Kgm.*	*Hours.*
52.....	May 31	385	40	0	6.848	0.000	1.6565	0.8206	125.8
49.....	June 3	380	60	0	10.270	.000	2.6340	1.2446	90.0
46.....	June 8	362	40	60	6.848	2.016	3.4730	1.5022	80.6
45.....	June 11	385	60	40	10.270	1.338	3.8400	1.5186	74.0
44.....	April 27	395	0	60	.000	2.016	1.8170	.5231	74.0
53.....	May 29	358	0	40	.000	1.338	1.2060	.3450	70.0

METHOD OF MAKING PHYSICAL ANALYSIS.—A quantity of each lot of residues of which an analysis was to be made was placed in a 1,200-c. c. shaking flask, after which distilled water was added to make up to 400 c. c. This was then shaken in a machine operated by motor for two hours at room temperature. The contents were placed on a brass screen with 2-mm. round holes; the mixing flask was cleansed, and the residue washed on the screen with 100 c. c. of distilled water.[1] The residue was removed from the screen to a mortar containing 50 c. c. of water and was ground very lightly; after this it was placed on the screen, 50 c. c. of water being used to clean the mortar. The whole was washed again with 100 c. c. of water, the process being repeated until the residue was apparently free from true feces or the finely divided particles. The corn-silage residue, the part left on the screen and designated as fraction "a" was then transferred to filter paper, dried, and weighed.

After fraction a had been removed, the filtrate washings were treated with 3 gms. of potassium aluminium sulphate, $[K_2SO_4.Al_2(SO_4)_3.24\ H_2O]$, placed in a mixing flask, made up to 1,000 c. c. with distilled water, shaken at room temperature for one hour, and allowed to stand a few minutes to permit partial sedimentation. It was then filtered by decantation and washed with distilled water until free from sulphates. The residue constituted fraction b. The filtrate with washings constituted fraction c, which for this study was not considered. After the separation had been completed, fractions a and b were dried in an oven at 105° C. to constant weight.

DISCUSSION OF RESULTS

The data presented in Table III provide material for making studies on the physical changes in feed that take place during the digestion of coarse feeds in cattle. This is especially true of the first two tests, in which silage alone was fed, to a lesser extent in case of the next two rations containing both silage and cottonseed meal, while for certain phases of this study the last two rations can not be considered, since the

[1] Distilled water was used for all purposes in making the separation.

feeds used were already finely divided and required no comminution. All the rations and tests give information on the time food remains in each organ.

TABLE III.—*Physical changes that occur during the digestion of coarse feeds in the stomach and intestines of cattle*

Steer No.	Gross weight of contents.	Percentage organ content is of body content.	Weight of dry matter in contents of organs.		Percentage of dry matter in contents of organs.		Percentage dry-matter content of organs is of total dry-matter contents.	Percentage dry-matter content is of organ contents.
			Above 2 mm.	Below 2 mm.	Above 2 mm.	Below 2 mm.		
	Kgm.		*Kgm.*	*Kgm.*				
RUMEN AND RETICULUM								
52	49.124	73.31	1.754	2.748	38.9	61.1	69.4	9.2
49	51.150	72.31	2.471	2.431	50.5	49.5	67.5	9.7
46	46.255	71.48	2.369	3.153	42.9	57.1	66.1	11.9
45	47.000	71.80	3.000	2.265	56.9	43.1	62.9	11.2
44	41.799	69.16	.000	2.171	.0	100.0	59.2	5.2
53	24.454	66.85	.000	1.326	.0	100.0	58.5	5.4
OMASUM								
52	7.460	11.14	0.352	0.779	31.1	68.9	17.5	15.2
49	8.140	11.49	.451	.803	36.0	64.0	17.3	15.4
46	3.775	5.83	.190	.613	23.7	76.3	9.6	21.1
45	4.900	7.48	.210	.757	21.7	78.3	11.5	19.8
44	4.890	8.10	.000	.467	.0	100.0	12.7	9.5
53	3.000	8.20	.000	.284	.0	100.0	12.5	8.3
ABOMASUM								
52	1.051	1.57	0.038	0.105	26.3	73.7	2.2	13.6
49	1.690	2.38	.067	.166	28.7	71.3	3.2	13.8
46	2.630	4.07	.120	.450	21.0	79.0	6.8	21.7
45	2.260	3.45	.080	.325	19.7	80.3	4.8	17.9
44	2.510	4.15	.000	.205	.0	100.0	5.6	8.2
53	2.019	5.52	.000	.156	.0	100.0	6.9	7.7
SMALL INTESTINE								
52	3.896	5.81	0.028	0.218	10.1	89.9	3.7	6.2
49	3.976	5.62	.044	.279	13.6	86.4	4.4	8.1
46	6.060	9.36	.030	.570	5.0	95.0	7.2	9.9
45	6.000	9.17	.053	.420	11.2	88.8	11.3	15.8
44	6.192	10.25	.000	.401	.0	100.0	10.9	6.5
53	3.100	8.47	.000	.196	.0	100.0	8.6	6.3
LARGE INTESTINE								
52	5.469	8.17	0.079	0.392	16.7	83.3	7.2	8.6
49	5.804	8.20	.102	.446	18.6	81.4	7.6	9.4
46	5.594	9.25	.225	.640	26.0	74.0	10.3	14.4
45	5.300	8.10	.145	.650	18.2	81.8	9.5	15.0
44	5.033	8.34	.000	.426	.0	100.0	11.6	8.5
53	4.008	10.96	.000	.307	.0	100.0	13.5	7.7

COMMINUTION

In but very few instances have efforts been made to measure the extent, efficiency, and results of the comminution of coarse feeds during the process of digestion. It has been recognized at all times that the comminution of feeds was important in order to obtain the most complete digestion. For example, old horses and cattle fail to fatten or secure the fullest benefits from coarse feeds consumed when their teeth become worn out or unsound, mastication being the most important step in the comminution of feed, as shown by our results. The extent of disintegration of coarse feeds is dependent on several factors, but from our figures it is evident that the comminution of silage is over 90 per cent efficient, with 2 mm. as the dividing line. The silage as fed was 100 per cent over 2 mm., while the residue of the feces over 2 mm. was in every case less than 20 per cent. Since the dry matter of the feces did not amount to 50 per cent of the dry matter of the feeds, it is quite apparent that over 90 per cent of the silage consumed was reduced from above 2 mm. to below 2 mm.

The data showing the amounts of the contents of the organs above and below 2 mm. furnish an indication of the extent of comminution taking place in the various organs. The extent of comminution is determined by difference, a method which possesses certain inaccuracies, but which is probably the best method applicable to our figures.

COMMINUTION IN MOUTH, RUMEN, AND RETICULUM

A small amount of comminution may take place during prehension. Most of it takes place, however, as a result of mastication, which may be of one or two kinds: The preliminary, to prepare the bolus for deglutition, or the final, which takes place much more slowly and completely when the animal ruminates.[1] In this study we can secure a measure of the total extent of comminution accomplished by mastication and rumination by knowing the condition of the food as it is fed the animal and by measuring the physical condition of the contents of the rumen, reticulum, and other organs.

A study of the data given in Tables IV and V shows that in the first two rations, which were made up of silage alone, the extent of comminution taking place before the food leaves the rumen and reticulum amounted to 65.8 per cent in the smaller ration and to 58.5 per cent in the larger ration. This is in accord with previous results,[2] when it was found that a smaller quantity of silage was comminuted to a greater extent than a larger quantity. When to these two rations were added the 60 and 40 per cent of cottonseed meal, an increase resulted in the extent of comminution of 5.1 and 10.5 per cent.

[1] SMITH, FREDERICK. MANUAL OF VETERINARY PHYSIOLOGY. Ed. 4, p. 157. London, 1912.
[2] EWING, P. V., WELLS, C. A., and SMITH, F. H. Op. cit.

TABLE IV.—*Extent of comminution in early stages of digestion and effect of absorption in later stages*

[Figures represent changes effected in reducing proportion of feed residues from above 2 mm. to below 2 mm.]

Stage of digestion.	Ration.			
	1	2	3	4
Mastication and one-half rumen and reticulum	61.1	49.5	57.1	43.1
One-half rumen and reticulum One-half omasum	7.8	14.5	19.2	35.2
One-half omasum One-half abomasum	4.8	7.3	2.7	2.0
One-half abomasum One-half small intestines	16.2	15.1	16.0	8.5
One-half small intestines One-half large intestines	− 6.6	− 5.0	−21.0	− 7.0
One-half large intestines	0.7	7.0	− 6.8	− 1.7

TABLE V.—*Calculated amounts of comminution taking place in the several organs during digestion*

Organ.	Ration.			
	1	2	3	4
Rumen and reticulum (including mastication)	65.8	58.5	70.9	69.0
Omasum	6.3	10.9	10.9	18.6
Abomasum	10.5	11.2	9.4	5.3
Small intestines	4.8	5.1	− 2.5	.8
Large intestines	−2.6	4.5	−17.3	−5.2

In making these observations on the extent of comminution in the rumen it should be noted that a portion of the last half-feed had undoubtedly not been ruminated. This discrepancy would not apply beyond the rumen and recticulum to an appreciable extent. The extent of comminution that takes place in the rumen and reticulum is in reverse order to the extent of comminution as a result of mastication. The most complete mastication occurred with ration 1, which was made up of a small amount of silage, while it is with this ration that the least comminution in the rumen and reticulum is indicated. The largest amount of comminution in the rumen and reticulum is in ration 4.

COMMINUTION IN OMASUM

In general, the amount of comminution that takes place in the omasum is rather constant, ranging from 6.3 to 18.6 per cent, the greater amount taking place with those rations made up of silage and cottonseed meal, and the least amount in the ration containing the smaller amount of silage alone.

COMMINUTION IN ABOMASUM

A more constant amount of comminution takes place in the abomasum than in the omasum, and the rations associated with the greater comminution are those made up of a higher percentage of coarse feeds, as in the silage alone.

COMMINUTION IN SMALL AND LARGE INTESTINES

Owing to the nature of digestion from a physical standpoint, the early part of the digestion period is consumed largely with a process of comminution and preparation, and comparatively little absorption takes place. During the later stages of digestion the extent of comminution is presumably much less, and absorption is much greater. The existence of this condition is brought out clearly in Tables IV and V, where it is seen that the extent of any comminution that takes place in the intestines is either partially or completely overshadowed by absorption. Since the absorption takes place much more rapidly with those particles under 2 mm. than with those over 2 mm., we obtain several negative percentage comminutions. The fact that the figures obtained for the intestines are composite figures representing two opposite effects, comminution and absorption, renders them of but little value in making deductions, since no method is available which will enable us to determine the extent of either factor alone.

RELATION BETWEEN TIME FOOD REMAINS IN ORGANS AND EXTENT OF COMMINUTION

A study of Tables IV to VI shows a relationship between the extent of comminution, the time the food residues remain in the organs, and the functional activities of the several organs. In general, the food residues remain the shortest time in the most active organs and the longest time in the most inactive. This is seen in the case of the abomasum, probably the most active organ functionally, in which food remains on the average only 2.83 hours, while in the rumen and reticulum, probably the most inactive functionally of all the organs, in which the food remains on the average over 60 hours, we find the extent of comminution not to be in proportion to the time. From a study of the figures it is seen that the extent of comminution is a resultant of two forces, time and functional activity, the functional activity being the stronger of the two influences. Thus, even though the food mass remain in the omasum for approximately three times as long as in the abomasum, the extent of comminution is about the same in both organs, the greater functional activity of the abomasum replacing the time factor in the omasum. As previously noted, the extent of comminution in the intestines is confused by absorption, so that no studies can be made on these data with reference to these relationships.

TABLE VI.—*Time required for the passage of residues through the several organs*

Organ.	Period of passage with ration No. —						
	1	2	3	4	5	6	Average.
	Hours.	*Hours.*	*Hours.*	*Hours.*	*Hours.*	*Hours.*	*Hours.*
Rumen and reticulum	92. 2	65. 0	57. 6	53. 0	51. 8	46. 8	61. 07
Omasum	14. 0	11. 4	4. 7	5. 5	6. 0	5. 7	7. 88
Abomasum	2. 0	2. 1	3. 3	2. 6	3. 1	3. 9	2. 83
Small intestines	7. 3	5. 2	7. 5	6. 8	7. 6	5. 9	6. 72
Large intestines	10. 3	7. 3	8. 0	6. 0	6. 2	7. 7	7. 58

To have made this study more complete would have required accurate measurements of the capacities of the several organs. However, the dry-matter contents of the several organs are probably the most satisfactory for making these studies. Some linear measurements of the several organs were made, and these are presented in Table VII.

TABLE VII.—*Linear measurements of organs*

Steer No.	Esophagus.	Abomasum.	Small intestines.	Large intestines.	Cæcum.[a]
	Meters.	*Meters.*	*Meters.*	*Meters.*	*Meters.*
52	1. 05	0. 74	41. 00	10. 00	0. 55
49	1. 10	. 75	39. 50	9. 80	. 58
46	1. 00	. 68	37. 10	10. 58	. 44
45	1. 00	. 69	39. 70	8. 72	. 53
44	1. 06	. 76	40. 00	10. 21	. 65
53	. 95	. 71	36. 75	7. 02	. 38

[a] Also figured in large intestines.

CONCLUSIONS

(1) More than half of the comminution that takes place in average rations containing coarse feeds takes place as a result of mastication.

(2) When rations are incompletely masticated, a higher percentage of the comminution takes place in the rumen and reticulum.

(3) About the same extent of comminution takes place in the omasum and abomasum.

(4) The amount of comminution is not alone dependent on the time food residues remain in the several organs, but it is also dependent on the functional activity of the several organs.

(5) Absorption takes place to the greatest extent in the intestines.

(6) Absorption tends greatly to lessen the quantity of residues below 2 mm. and proportionately to increase that above 2 mm.

(7) The comminution of silage-alone rations during the process of digestion is over 90 per cent efficient, with 2 mm. as the dividing line.

SUNSCALD OF BEANS[1]

By H. G. MACMILLAN

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INTRODUCTION

The seed-bean industry is new in northern Colorado. In the Greeley district eastern seed houses contracted for 3,000 acres in 1916; 10,000 in 1917; and it is estimated that 25,000 acres will be contracted for in 1918. Forty thousand acres in Weld County were in beans (*Phaseolus vulgaris*), both seed and commercial, in 1917, the acreage having been distributed among 27 varieties. Yields of 35 to 45 bushels per acre indicate that irrigation and climatic conditions are favorable to bean production. Anthracnose is rare; rust appears only where rotation has been neglected; bacterial-blight is yet uncommon.

Late in 1916, before the beans had been harvested, a spotting and streaking[2] of bean pods generally was observed. In all stages it had the appearance of a bacterial infection. Microscopic examination was made of the traumatic tissue; but no bacteria, or suggestion of bacteria, were found. Cultures were made on beef agar, potato agar, bean agar, string beans, and in beef bouillon; but no organism developed, other than an occasional contamination.

THE DISEASE

In northern Colorado beans are planted about May 20. By planting 60 pounds of seed to the acre in rows 28 inches apart a heavy stand of vine is obtained. After three irrigations the pods are well filled and approaching maturity. Usually no water is applied after the middle of August. From this time on, the leaves gradually desiccate and curl exposing the ripening pods beneath. Then the spotting appears. At this period the green stage has passed, and the pods are whitening.

The first indications of disease are very tiny brown or reddish spots upon the upper or outer valve away from the center of the plant. These spots gradually lengthen until they appear as short streaks running backward and downward from the ventral toward the dorsal suture. In two days the spots have increased to areas of brown water-soaked tissue, some-

[1] This problem was originally taken up as a joint problem with Prof. W. G. Sackett, Bacteriologist of the Colorado Agricultural Experiment Station, but his absence from the State in the fall of 1917 made another arrangement necessary. However, the writer is indebted to Prof. Sackett for the results of some microscopical and cultural study.

[2] This "streak" was first mentioned by (Sackett SACKETT, W. G. DISEASES OF BEANS. *In* Colo. Agr. Exp. Sta. Bul. 226, p. 21–31, 6 fig. 1917.)

times slightly sunken. If the spread has been rapid, the color is a good brown, sometimes tinged with red, extending over a majority of the exposed surface, and sometimes over all of it. On some varieties the entire exposed surface does not become covered, but spots 3 to 4 mm. in diameter grow to be the largest, while new spots are constantly appearing. Often small spots coalesce into larger ones, giving them an irregular shape. Eventually this spotting may appear on the underside of the pod, but always in lesser quantity. From these spots no organism has been cultured or observed.

EXPERIMENTAL WORK

From August 15 to September 15, 1917, the average maximum temperature was 27.2° C. at the experiment station at Greeley. No extremes of weather were experienced. There were four partly clouded days; rain fell three times in small amount. At this altitude (4,700 feet) the days during this period were warm and clear, and the heat of the sun seemed very intense.

In those varieties which early showed the lack of water the disease was apparent by August 20. On September 1 some beans of the Green Bountiful variety showed spotting. Plate 64, A, shows six bean pods which were exposed to the sun naturally on the plant and had become well spotted. Plate 64, B, shows the reverse side of the same six pods, but only faint indications of spotting appear in slight amount.

On September 6 experiments were begun in a field of the Bountiful variety.[1] A small table was constructed of four stakes and a muslin sack so placed that one edge came close to a number of bean pods. Pods showing no spotting, and still naturally attached to the plant, were laid on top of the sack, exposed to the sun. Other pods from the same stalk were slipped through a slit made in the edge of the sack in such a manner that the lower sheet of the sack supported the pod in approximately the same position as the exposed pod, while the upper sheet covered it. This gave each pod practically the same conditions and position, except that one was covered with a single covering of thin muslin. All shading leaves were removed, and the table was exposed to the full strength of the sun's rays. Early in the morning the muslin was wet with dew, and any spores or bacteria which might have infected the exposed bean pods had an equal or better chance for contact with the covered one.

Spotting quickly appeared on the exposed pods, while none appeared on the covered ones. On September 13 the experiment was discontinued, and a photograph taken (Pl. 65, A). The pod which went through the experimental period covered is shown at the right, removed from the sack; there is complete absence of spotting. The pod at the left was exposed in the position shown, and is characteristically spotted. The results of seven trials were identical in every way.

[1] The Bountiful variety should not be confused with the Green Bountiful variety used above.

On September 6, bean pods which showed very slight spotting and some showing none at all were tied in muslin sacks and left until September 13. The leaves were removed and no shade covered the plants at any time of the day. Four groups of these pods are shown in Plate 65, B, and are as free from spotting as when placed in the sacks. The two pods at the left show slight traces, which was the condition on September 6.

On September 8 the original experiment was repeated on pods of the Refugee Wax variety. The tables were constructed of stakes and muslin sacks; and pods free from spotting were exposed and inserted in the sacks. The experiment was discontinued on September 16, with the same result as in the previous case. Plate 66, A, shows the results of one of these trials. The pods were placed on a mirror for photographing. On the right is one pod which was half-inserted in the sack, the lower half showing no spotting, the upper half being heavily spotted. The pods at the left were exposed on the table and are heavily spotted on the upper surface; but the lower surface, as revealed in the image, shows no spotting. The two pods at the center were not included in the experiment, but hung naturally on the plant, partially shaded.

In a field of the Hardy Wax variety, in which the leaves were yet green, owing to late irrigation, plants were found which had been crowded over by the wind. Exposed pods were spotted. On the stalks and branches also, long, brown streaks were observed which appeared to be due to the same cause. These streaks were only on the side exposed to the sun. A plant of this type is illustrated in Plate 66, B.

CAUSE OF THE DISEASE

The spotting and streaking of the pods and the streaking of the stems and branches is due to sunscald. When the pods are shaded, as in leafy varieties, little or no spotting occurs. The tissue is bacteriologically sterile.

ECONOMIC IMPORTANCE

No loss is caused by sunscald. Bean pods have been found which were so severely scalded that the seed coats within were slightly stained, but no ill effects were to be observed. Seed saved from pods severely scalded in 1916 and planted in 1917 were normal in every respect. There was no decrease in yield, nor lack of vigor. The pods filled normally, and scalding occurred again as it had done before.

The danger is that the sunscald may be mistaken for bacterial-blight, or that bacterial-blight may be disregarded for scald. Bean pods examined at several places in the East were spotted very finely by spots closely resembling the ones described above. They were diagnosed by pathologists as bacterial-blight spots, because they were so common and had the characteristics of incipient blight infection. Spots of some few examined were not bacterial, and were believed to be slight touches of sunscald.

CONCLUSIONS

The spotting and streaking of bean pods and stems, herein described is due to sunscald.

No damaging effects due to this scalding have been observed.

The scalding is diminished or prevented by the shade of leaves, but when these wither, it may occur in a period of six days.

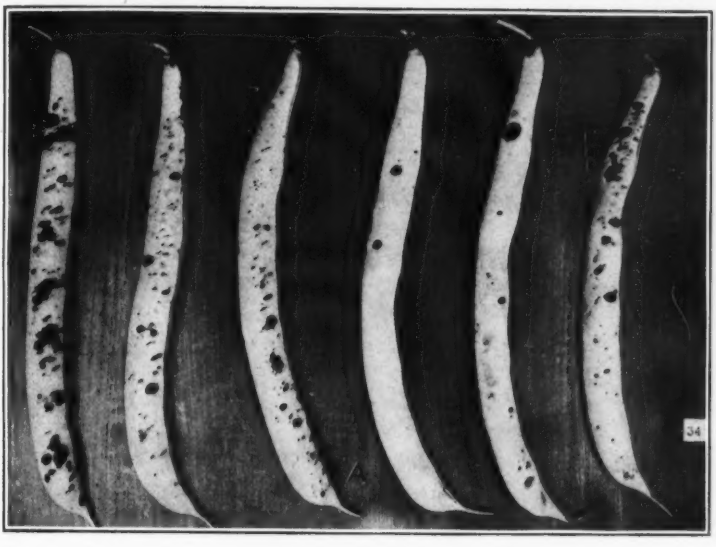
No varieties of beans have been observed to be immune from sunscald where sufficiently exposed.

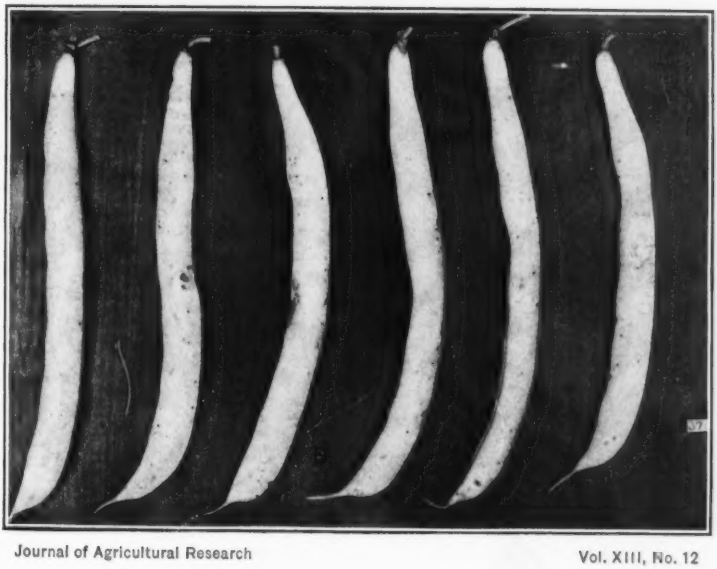
At certain stages of the disease the appearance may easily be mistaken for bacterial infection, and can not be differentiated except upon examiation under the microscope.

PLATE 64

A.—Six pods of the Green Bountiful variety of beans which showed natural sunscald on September 1.

B.—Reverse side of the six pods shown in A.





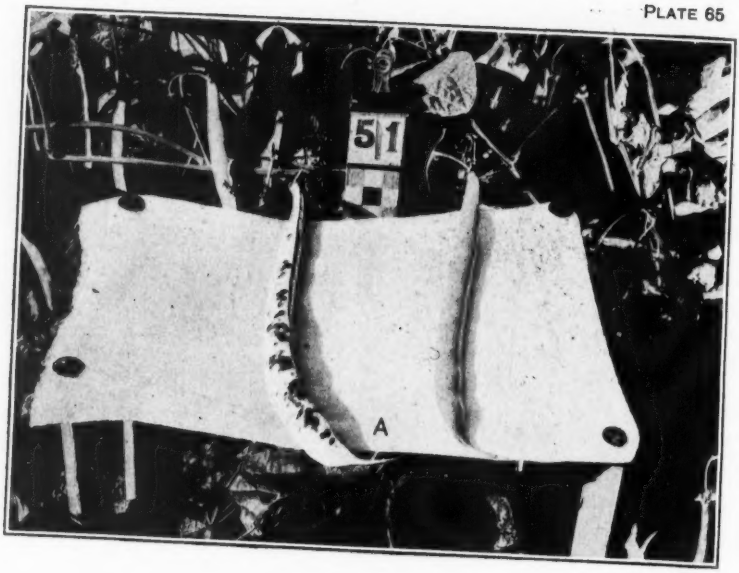

51
A

PLATE 65

A.—Two pods of beans, the one at the left injured by sunscald, the one at the right having been protected from the rays of the sun. The pod at the left was exposed to the sun in the position shown. The pod at the right was covered by slipping it through a slit on the back edge of the muslin sack.

B.—Four groups of bean pods exposed tied in muslin sacks. The two at the left were slightly spotted as shown when the experiment began.

PLATE 66

A.—Refugee wax beans. The pod at the right was exposed for one-half its length. The image in the mirror shows the freedom from spotting of the underside of the exposed pods.

B.—Hardy wax beans, showing sunscald on the stems, branches, and pods.

53
A

55
B

A THIRD BIOLOGIC FORM OF PUCCINIA GRAMINIS ON WHEAT[1]

[PRELIMINARY PAPER

By M. N. LEVINE, *Field Assistant, Office of Cereal Investigations, Bureau of Plant Industry, United States Department of Agriculture,* and E. C. STAKMAN, *Head of the Section of Plant Pathology, Department of Agriculture, University of Minnesota*

COOPERATIVE INVESTIGATIONS BETWEEN THE AGRICULTURAL EXPERIMENT STATION OF THE UNIVERSITY OF MINNESOTA AND THE BUREAU OF PLANT INDUSTRY OF THE UNITED STATES DEPARTMENT OF AGRICULTURE[2]

Two biologic forms of stemrust have been known to occur on wheat. *Puccinia graminis tritici* Erikss. and Henn. was the only one recognized until recently, when *P. graminis tritici-compacti* Stak. and Piem. was discovered.[3]

Stemrust collected on clumps of volunteer wheat at Stillwater, Okla., October 18, 1917, was found to be different parasitically from both *P. graminis tritici* and *P. graminis tritici-compacti.* Immediately after collection it was sent to University Farm, St. Paul, Minn., where inoculations were begun to determine its identity. It was cultured for several generations on Brown Gloria club wheat, Haynes bluestem (Minn. 169), and Manchuria barley (Minn. 105), during which time its identity was in doubt. Spore measurements made during the same time appeared to indicate that the rust was neither *P. graminis tritici* nor *P. graminis tritici-compacti.*

The discovery of *P. graminis tritici-compacti* and subsequent work with it showed clearly the value of using differential hosts to distinguish between different biologic forms. It has been shown previously[4] that two or more biologic forms could infect many grasses and some cereals equally well but that their action on at least one of the common cereals—wheat, barley, oats, and rye—was sufficiently different to make their determination simple. For instance, *P. graminis tritici* and *P. graminis secalis* attack many grasses and barley equally well; oats are almost immune from both; but the *tritici* form attacks rye only weakly and attacks common wheats heavily, while the *secalis* form attacks rye heavily and

[1] The writers are under obligation to Dr. Charles Drechsler, Field Assistant, Office of Cereal Investigations, Bureau of Plant Industry, U. S. Department of Agriculture, for participating in the collection of the original material: to Mr. G. R. Hoerner, Assistant in Plant Pathology, Minnesota Agricultural Experiment Station, for the preliminary inoculations: and to Mr. J. G. Leach, Shevlin Fellow, University of Minnesota, for valuable suggestions and for many of the data on the differential hosts for *P. graminis tritici* and *P. graminis tritici-compacti.*

[2] Published, with the approval of the Director, as Paper 121 of the Journal series of the Minnesota Agricultural Experiment Station.

[3] STAKMAN, E. C., and PIEMEISEL, F. J. A NEW STRAIN OF PUCCINIA GRAMINIS. *In* Phytopathology, v. 7, no. 1, p. 73. 1917.

[4] STAKMAN, E. C., and PIEMEISEL, F. J. BIOLOGIC FORMS OF PUCCINIA GRAMINIS ON CEREALS AND GRASSES. *In* Jour. Agr. Research, v. 10, no. 9, p. 429-496, pl. 53-59, 1917. Literature cited, p. 493-495.

can not infect wheat. Rye and wheat are, therefore, differential hosts for the two forms. But the *tritici* and the *tritici-compacti* forms can not be distinguished from each other by their action on grasses, soft wheats, oats, barley or rye. The differential hosts for these two forms are less widely separated taxonomically. It is only by their action on a limited number of different varieties of wheat that they can be distinguished; but the differences on the varieties which do serve as differential hosts are extremely sharp and very consistent.

In order to definitely establish the identity of the rust in question, it was further cultured on the following differential hosts for *P. graminis tritici* and *P. graminis tritici-compacti* (in addition to those mentioned above): Kanred P762 (Kans. 2401), P1066 (Kans. 2415), P1068 (Kans. 2414), Barletta (Minn. 1178), Marquis (Minn. 1239), and Royalton (Minn. 1037)—all *vulgare* wheats.

Club wheat has been found by Stakman and Piemeisel [1] to be highly susceptible to both *P. graminis tritici* and *P. graminis tritici-compacti*, while Haynes bluestem was found very susceptible to the *tritici* form and highly resistant to *tritici-compacti*. The Kansas varieties, P762, P1066, and P1068, have been described by Melchers and Parker [2] as decidedly resistant to *P. graminis tritici compacti* under greenhouse conditions. Barletta, Marquis, and Royalton, on the other hand, are extremely resistant to *P. graminis tritici-compacti*. Inoculation experiments proved all of these varieties to be very suspceptible to the rust found in Oklahoma. The results of the inoculations, which extended over a period of six months, during which 10 successive transfers were made, are given in diagram 1.

This diagram shows that all the wheat varieties tested were susceptible to the new rust. These varieties, as already mentioned, are differential hosts for *P. graminis tritici* and *P. graminis tritici-compacti* (Table I). By using these differential hosts it was possible to ascertain that the new rust was not a mixture of *P. graminis tritici* and *P. graminis tritici-compacti*.

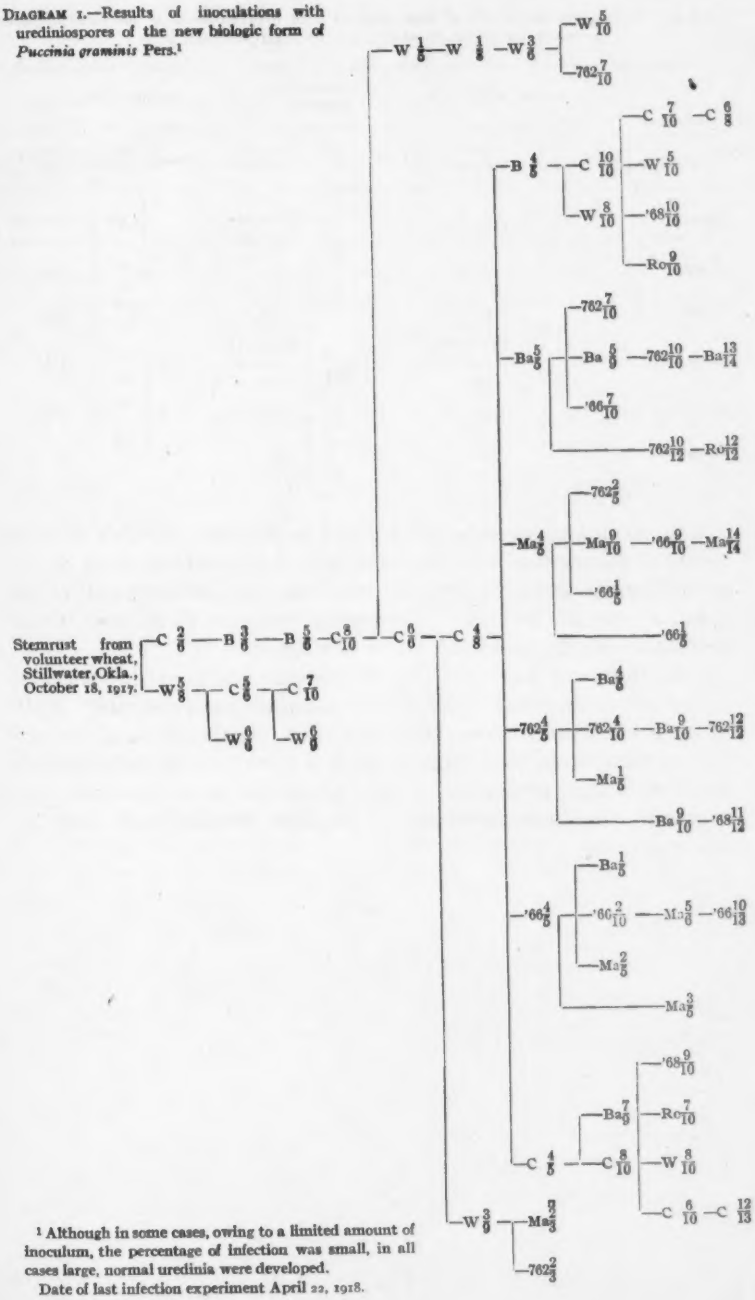
EXPLANATION OF DIAGRAM 1

In diagram 1 Haynes bluestem wheat is represented by W, club wheat by C, Kanred P762 by 762, P1066 by '66, P1068 by '68, Barletta by Ba, Marquis by Ma, Royalton by Ro, and barley by B. Transfers are indicated by dashes; thus, C—B—means that the rust was transferred from club wheat to barley and all other hosts indicated in the same vertical column, as Ba (Barletta), Ma (Marquis), 762 (Kanred P762), etc. The results of inoculations are represented in the form of a fraction, the denominator indicating the total number of leaves inoculated and the numerator the number which became infected.

[1] STAKMAN, E. C., and PIEMEISEL, F. J. OP. CIT.

[2] MELCHERS, L. E., and PARKER, J. H. THREE VARIETIES OF HARD RED WINTER WHEAT RESISTANT TO STEM RUST. *In* Phytopathology, v. 8, no. 2, p. 79. 1918.

DIAGRAM 1.—Results of inoculations with urediniospores of the new biologic form of *Puccinia graminis* Pers.[1]



[1] Although in some cases, owing to a limited amount of inoculum, the percentage of infection was small, in all cases large, normal uredinia were developed.

Date of last infection experiment April 22, 1918.

TABLE I.—*Comparative results of inoculations with uredinospores of the three biologic forms of Puccinia graminis Pers. on six differential hosts*

Differential hosts.	*P. graminis tritici.*			*P. graminis tritici-compacti.*			The new biologic form.		
	Trials.	Result.	Degree of infection.	Trials.	Result.	Degree of infection.	Trials.	Result.	Degree of infection.
P762 (Kanred)	3	0/52	Immune.	2	17/18	Semiresistant.	9	58/77	Very susceptible.
P1066.....	2	0/23	...do.....	3	18/30	...do.....	7	34/58	Do.
P1068.....	3	0/32	...do.....	4	18/37	...do.....	3	30/32	Do.
Barletta..	4	35/37	Very susceptible.	17	23/174	Highly resistant.	8	53/69	Do.
Marquis...	2	17/18	...do.....	4	16/31	...do.....	8	40/53	Do.
Royalton .	1	8/9	...do.....	4	40/40	...do.....	3	28/32	Do.

Table I contains the summary of these inoculations, together with the results of inoculations with the *tritici* and *tritici-compacti* forms on the six differential hosts. It will be seen from this table that all of the varieties resistant to either *P. graminis tritici* or *P. graminis tritici-compacti* are highly susceptible to the new form.

From the above facts it is evident that the rust found in Oklahoma is neither *P. graminis tritici* nor *P. graminis tritici-compacti*. While only a few differential hosts have been tried, yet the action of the new rust on these hosts is so entirely different from that of the previously described biologic forms, that it must be considered as a distinct form, Extensive cross inoculations and an intensive morphological study are now under way.

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